THE

OIL-CHEMISTS' HANDBOOK.

BY

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FIRST THOUSAND.

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TO

Leonard Parker Kinnicutt, D.Sc.,

IN

GRATEFUL ACKNOWLEDGMENT

OF

HIS UNTIRING KINDNESS

AS

TEACHER AND FRIEND,

THIS BOOK IS DEDICATED.

INTRODUCTION.

A DESIRE has long been felt among those interested in oil-testing, whether as manufacturers, dealers, or chemists, for some practical working manual containing not only the methods used in testing and analyzing oils, but also giving, in a convenient and comprehensive form, the vast amount of analytical data by which an unknown oil can be identified, an adulterated oil easily detected, and the oil used as the adulterant determined. This handbook has been written with the hope of serving the above purpose.

In this book will be found a clear and concise description of the standard methods used for testing oils, modified, in certain cases, from experience gained in the author's laboratory. Particular attention has been paid to such determinations as "acid value," "saponification number," "iodine number," "acetyl value," and the other well-known tests for oils, but it also contains the methods used in examining "fatty acids" and the determination of such substances as "resin," "lactone," and "glycerol."

One of the chief features of the manual is the arrangement of the analytical data, the oil constants. These constants, compiled from original sources, have been tabulated with the greatest care; maximum, mean, and minimum values have been given in all cases, and the tables are believed to be the most complete ever published in book form. The arrangement of these tables differs from that found in any of the well-known books on oils in that the oils are not given in their alphabetical order, but their position in the various tables depends on the numerical value of their constants; thus in the table of iodine absorption constants sardine oil stands first, while in the table of acetyl values castor oil heads the list. This arrangement it is believed will greatly facilitate the identification of an unknown oil.

While this book does not contain any great amount of absolutely

original material, it is by no means a mere compilation, but embodies the results of many years of practical experience, and contains all the data the author has worked out for his own convenience and use.

Its name clearly indicates its character; it is an oil-chemist's handbook, and when used as such it will be found to be a valuable aid to all those engaged in oil-testing.

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OIL-CHEMIST'S HANDBOOK.

CHAPTER I.

CONSTITUTION AND GENERAL PROPERTIES OF OILS, FATS, AND WAXES.

THE Handbook has to do with fixed oils, fats, and waxes as met with in commerce.

Fixed oils and fats are here considered; the hydrocarbon oils are considered only so far as they enter into combinations with fixed oils and fats as adulterants.

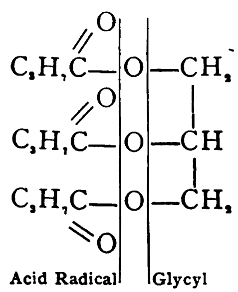
It can be said that fixed oils are liquid glycerides which are liquid at ordinary temperature, and the term fixed fats applies to such glycerides as are not liquid at ordinary temperature.

Fixed oils contain more liquid glycerides than do fixed fats.

In chemical composition all fixed oils, including fats, are organic salts of organic acids; i.e., the organic radical (CH) takes the place of the replaceable (H) of the organic acid.

These salts are called glycerides, as the (H) of the organic acid is replaced by one of the (CH) groups of glycerol; or, in other words,

Glycyl $\left(\begin{array}{c} -CH_2 \\ | \\ -CH \\ | \\ -CH_2 \end{array}\right)$; and the acid radicals form the glycyl salts of the organic acids; their general formula being $\begin{array}{l}(\text{Acid Rad.})_3 \\ C_3H_5\end{array}\!\!>O_3$.

The glyceride of butyric acid in butter = 

Glycerol, a trihydric alcohol, is able to combine with three monovalent acid radicals and form triglycerides.

Most oils do not differ so much in the glycerides they contain as in the amount of glycerides contained in each; but, with this statement, it must be remembered that various glycerides also give character to an oil and fat.

The principal acids found in oils are:

$C_NH_{2N+1}\overset{O}{\overset{\parallel}{C}}\text{—}OH,$	Palmitic Acid,	$C_{15}H_{31}COOH.$
	Stearic Acid,	$C_{17}H_{35}COOH.$
$C_NH_{2N-1}\overset{O}{\overset{\parallel}{C}}\text{—}OH,$	Oleic Acid,	$C_{17}H_{33}COOH.$
$C_NH_{2N-3}\overset{O}{\overset{\parallel}{C}}\text{—}OH,$	Linoleic Acid,	$C_{17}H_{31}COOH.$
$C_NH_{2N-1}O\text{—}\overset{O}{\overset{\parallel}{C}}\text{—}OH,$	Ricinoleic Acid,	$C_{17}H_{33}OCOOH.$

Waxes are allied to oils and fats, but differ from them in that the organic radical is not glycyl, but a monovalent radical, as an aliphatic alcohol.

Oils are divided into three classes, based on their possession or lack of the property of "drying."

(1) Drying oils, the best known being linseed, hemp-seed, poppy-seed.

(2) Semi-drying oils, such as maize, cotton-seed, sesame, rape, and castor.

(3) Non-drying oils, like arachis, olive, all fish oils (excepting sperm), all animal oils and fats, all vegetable fats.

Sperm oil, although containing many properties similar to other fish oils, has been placed among the waxes, as the representative of liquid waxes. Sperm oil contains 35–40% of monovalent aliphatic alcohols and only the smallest trace of glycerol, and for this reason it would seem that sperm oil represents a wax rather than an oil.

The waxes, excepting the two sperm oils, are solid and brittle at ordinary temperature.

OIL.	SOURCE.	PROCESS OF MANUFACTURE.	COLOR.	ODOR.	TASTE.	
LINSEED	Seeds of Flax Russia: Baltic, best Black Sea, 2d India: East Indian, 3d S. America: River Plate, 4th	*Pressing.* *English* *American* Crushing Crushing Grinding Heating Heating Moulding Pressing Pressing Refining Refining	Cold-pressed, Golden yellow High-temp. pres. yellow-brown	Characteristic Oil from hot pressure more acrid	Characteristic	On exposure to ai oil becomes easil rancid Thin layer dries t neutral substan called "Linoxyn insoluble in wate alcohol, ether
HEMP-SEED	Seeds of Hemp	Pressing	Fresh, light green to green-yellow Oil, brown-yellow	Characteristic	Mild	Dries easily
WALNUT	Seeds of Walnut Tree	Seeds must be very ripe and kept 2-3 months before being pressed, to give clear oil If seeds are fresh, oil is turbid	Cold-pressed, nearly colorless to pale yellow Hot-pressed, greenish tint	Pleasant Acrid	Nutty Acrid	Equal, if not sup rior to, Linseed O
POPPY-SEED	Seeds of Poppy	Pressing	White Poppy-seed Oil, colorless to light yellow, cold-pressed Red Poppy-seed Oil, brown, hot-pressed	Slight	Pleasant to acrid	Does not turn rancid; good dri
MAIZE	Seeds of Maize Plant	Express seeds before manufacture of starch Express residue of fermentation vats after manufacture of alcohol (Char. by large amt. of Free Fatty Acids)	Pale yellow Red-brown	Slight	None	Almost no dryi power
COTTON-SEED	Seeds of Cotton-seed Tree	Expressed Refined by alkalis	Crude, red to black Refined, pale yellow	Slight	None	Type of semi-di ing oil
SESAME GINGILI-TEEL	Seeds of Sesame Plant	Expressed	Yellow	None	Pleasant	Very weak dryi power
RAPE-SEED COLZA	Seeds of Cruciferæ Brassica Campestris	Extraction Expression Refined with conc. H_2SO_4	Yellow	Characteristic	Unpleasant Harsh	Intermediate b tween semi-di ing & non-dryi Oil thickens a becomes ranci but does not dr
CROTON	Seeds of Croton Tiglium	Extraction Expression	Yellow Orange or brown when old	Nauseous	Burning	Weak-drying oi

GLYCERIDES.	CHARACTERISTIC TESTS.	ADULTERANTS.	USE.	OTHER OILS OF GROUP.
10–15% Solid Fatty Acids { Stearic, Palmitic, Myristic 90–85% Liquid { 5% Oleic, 15% Linoleic, 15% Linolenic, 65% Isolinolenic	Maumene, Iodine Livache, Elaidin	Rape and Cotton-seed Oil groups; told by low Iodine and sapon. value Fish Oils; told by odor and high Iodine Mineral Oil, Resin Oil { told by unsapon. matter	Soap stock Paints and varnish Rubber substitute	**VEGETABLE OILS.** **Drying.** Lallemantia Niger-seed Sunflower Madia Fir-seed Candle-nut Japanese Wood Garden Rocket Tobacco-seed Weld-seed
Solid { Stearic, Palmitic Liquid: Principally Linoleic, also Oleic Linolenic Isolinolenic	Same		Same	
Solid { Myristic, Lauric Liquid: Principally Linoleic, also Oleic Linolenic Isolinolenic	Same	Linseed Sesame Arachis	Artists' paints, especially white. Varnish less liable to crack than that from Linseed Soap (?)	
Solid { Stearic, Palmitic Liquid { 65% Linoleic, 5% Linolenic, 30% Oleic	Same	Rarely adulterated Sesame	Salad—adulterate Olive Artists' paints Soap (?)	
45% Oleic 50% Linoleic 5% Stearic also Cholesterol Licithin (Hopkins)		Mineral Oil, Resin Oil { told by unsapon. matter	Burning and Lubricating Oils To adulterate lard. Paints	**Semi-drying.** (1) COTTON-SEED OIL GROUP. Cameline (German Sesame) Kapok Soja Bean Pumpkin-seed Beechnut Brazilnut
Solid { Stearic, Palmitic Liquid { Oleic, Linoleic also, Hydroxy Acids	Melting point and solidifying point of Fatty Acids Iodine value of Liquid Fatty Acids Becchi's test Elaidin test	Linseed (?) Mineral Oil Resin Oil	To adulterate Olive Oil, Lard, Butter Salad and general cooking use To make Butter substitutes General manufacturing purposes	
Solid { Stearic, Palmitic Liquid { Oleic, Linoleic also, Resinous substance	Baudoin test	Poppy-seed; told by Iodine (Maumene) Arachis Cotton-seed (Becchi and Livache) Rape-seed (sapon. value)	Edible Oil Soap making Perfumery Burning Oil	
Stearic Oleic Erucic and Rapic Behenic or Arachidic (?) also Phytosterol	Livache Sapon. value very low Viscosity	Drying Oils, Fish Oils { told by Iodine, Maumene, sapon. viscosity, sp. gr. Cotton-seed Mineral Oils Resin Oils	Burning	(2) RAPE-OIL GROUP. Garden Cress Hedge Mustard Black Mustard White Mustard Radish-seed Jambo
Stearic, Palmitic, Myristic, Lauric, Valeric, Butyric, Acetic, Formic, Oleic, Tiglic Crotonoleic	Gives no Elaidin Soluble in Petroleum Ether	*Castor-test.*—Heated in silver dish with KOH, gives off Capryl Alcohol. Boil residue, and Sebacic Acid crystallizes out	Powerful purgative medicinal	(3) CASTOR-OIL GROUP. Curcas Grape-seed

OIL.	SOURCE.	PROCESS OF MANUFACTURE.	COLOR.	ODOR.	TASTE.	
CASTOR	Seeds of Ricinus Communis	Extraction Expression	Colorless to pale green	Mild	1st mild 2d harsh American more harsh than Italian and French	Viscous Thickens on exposu to air but does not d
ARACHIS	Peanut or Earth-nut	Pressing	Colorless	Bean	Bean	
OLIVE	Olives	Pressing Extracting	Colorless to yellow	Mild	Pleasant	Type of non-dryin
OLIVE-KERNEL	Stones of Olives	Pressing Extracting	Green-brown	Rancid Olive	Rancid Olive	More soluble in alco than Olive
MENHADEN	Body of Menhaden	Boiling with water	Brown	Fish	Fish	Drying property
SARDINE	Body of Sardine	Boiling and rotting	Yellow-brown	Fish	Fish	
COD LIVER	Liver of Cod Fish	Steaming Boiling	Pale yellow to brown	Fish	Fish	
SEAL	Blubber of Seal	Boiling with water	Light yellow to brown	Fish	Fish	
WHALE	Blubber of Whale	Same	Yellow-brown to brown	Fish	Fish	
DOLPHIN BLACKFISH	Blubber of Blackfish [Fish Special, Jaw of	Same	Light yellow Jaw—straw color	Fish	Fish	Deposits spermacet time
PORPOISE	Body of Porpoise	Same	Straw to brown	Fish	Fish	Does not deposit spermaceti [70 Jaw sol. in alcoho Body insol. in alc at 70° C.
NEAT'S FOOT	Feet of Ox	Boiling with water	Light yellow	Slight	Bland	Deposits stearin Does not easily bec rancid
SHEEP'S FOOT	Feet of Sheep	Same	Yellow	Slight	Bland	Same
HORSE'S FOOT	Feet of Horse	Same	Yellow	Slight	Bland	Same
LARD OIL	(1) Hog's Leaf Lard [Lard (2) Whole Hog	Pressing	White to light yellow	Lard	Lard	Bleaches in light
TALLOW OIL	Mutton and Beef Tallow	Pressing	Light yellow	Tallow	Tallow	Bleaches in light

	GLYCERIDES.	CHARACTERISTIC TESTS.	ADULTERANTS.	USE.	OTHER OILS OF GROUP.
ire lry	Stearic Ricinoleic Ricinisoleic Sebacic Hydroxy Acids	Highest sp. gr. of natural oil [Ether Insol. in Petroleum Highest viscosity of all oils excepting "Blown" and Resin Oils Acetyl Value Sapon. Iodine Values *Qual. Test.*—Few drops of oil & 5 drops HNO_3—neutralize with Na_2CO_3 = Oenanthylic Acid (smell)	Resin of high sp. gr. Linseed Sesame Rape-seed Cotton-seed "Blown" Oils from Linseed	Medicinal Soap stock Alizarine assistant	
	Arachidic Oleic Linoleic	Arachidic Acid	Poppy-seed (Iodine) Sesame (Bandouin) Cotton-seed	Salad Burning Soap stock	**Non-drying.**
g	30% { Stearic Palmitic } 70% Oleic trace Arachidic also Cholesterol — *only vegetable oil*	Elaidin, *low* Iodine Maumene, lowest of veg. oils	Arachis (Iodine) Sesame (Baudouin) Cotton-seed (Livache and Becchi) Rape (sapon. value) Castor and Curcas Lard Oil Drying Oils Fish Oil Mineral Oils	Eating Lubricating Burning Soap stock Alizarine assistant	Cherry-kernel Cherry Laurel Apricot-kernel Plum-kernel Peach-kernel Almond Sanguinella Rice Tea-seed Pistachio Hazelnut
iol	Like Olive, but more free Acid	Like *Olive*	Mineral Oils	Soap stock and general manufacturing purposes.	Coffee-berry Ungnadia Ben
	?		Mineral Oil	Currying leather [Oil Manufacture of Sod Adult'e Linseed Oil	**ANIMAL OILS.** **Marine.**
	Palmitic Jecoric } ? Asellic		Mineral Oil Cheap Fish Oil		(1) FISH-OIL GROUP. All Fish Oils
	Palmitic Stearic ? and Cholesterol	Cholesterol, Acid value, Reichert, Meissl Unsap. matter	Cheap Fish Oils Liver Oils Blubber Oils Mineral Oils Resin Oils Vegetable Oils	(Pale) pharmacy (Brown) currying leather Manufacture of Sod Oil	(2) LIVER-OIL GROUP.
	?		Resin Oil	Lubricating To adulterate Whale	(3) BLUBBER-OIL GROUP.
	Palmitic ?		Seal	Burning Currying leather [Oil Manufacture of Sod	
in	Volatile acids ?	Reichert-Meissl		Lub icating delicate machinery	
C. at iol	Palmitic, Stearic, Valeric, Oleic	Reichert-Meissl			
ne		Iodine, Maumene, unsapon. matter	Fish, Rape, Poppy-seed, Cotton-seed Mineral & Resin Oils Sheep's Foot and Horse's Foot Oils Hard to find pure	Lubricating	**Terrestrial.**
				Same To adulterate Neat's	
				Same To adulterate Neat's	
	Oleic (almost entirely) Stearic (little)	Like Olive, Maumene, and Elaidin		Eating, lubricating, burning	
	61% Stearic 6% Palmitic 33% Oleic			Lubricating	

OIL.	SOURCE.	PROCESS OF MANUFACTURE.	COLOR.	ODOR.	TASTE.	
COTTON-SEED STEARIN	Cotton-seed Oil	Chilled "Bagged" Pressed	Colorless to pale yellow	Slight	Slight	
VEGETABLE TALLOW OF CHINA	Seed of Chinese Tallow-tree	Extraction	White	None	None	Hard and brittle, n grease spot on pa
PALM OIL	Fleshy part of Fruit of Palm-tree of West Africa	Rotting and expressing	Orange to red	Fresh—violet Old—disagreeable, rancid	Sweet	Consistency. Like Hard Butter: Lagos Like Tallow = Co Large amount of F Fatty Acids Bleached by air, h or chemicals
COCOA BUTTER	Cocoa-bean	By-product in manufacture of Chocolate	Light yellow	Chocolate	Chocolate	
PALM-NUT OIL	Kernels of Palm-nuts	Pressing Extracting	White	Pleasant	Pleasant	Strong caustic, n sary for soap-ma
COCOANUT OIL	Kernels of Cocoanut	Pressing Extracting	White to yellow	Agreeable	Agreeable	Varies Cochin turns e Ceylon solid [r Coprah
MYRTLE WAX	Berries of Myrtle	Boiling with water	Green (chlorophyll) White on exposure to air	Feeble	Feeble	Harder than Bee
JAPAN WAX	Berries of several Sumac-trees of Japan and China	Boiling with water Extracting with solvents	Pale yellow White (bleached)	Tallow and beeswax	Slight	Hard
HORSE FAT	Body of Horse	Boiling	Light yellow			
GOOSE FAT	Body of Goose	Boiling	Light yellow			
LARD	Hog's Fat from (1) Kidney and bowels (2) All Fats	Tried out and pressed	White	Characteristic	Characteristic	
BEEF MARROW	Bone-marrow of Cattle	Boiling	White	Slight to disagreeable	Slight to disagreeable	
BONE FAT	(1) Bones of Cattle & Horses (2) Putrid Bones of every description	Boiling Extracting by solvents or extraction	White and yellow to brown	Disagreeable	Disagreeable	
BEEF TALLOW	Fat of Cattle	Rendered at 100° C.	Fresh-white Green to yellow	Fresh—not unpleasant to rancid	Tasteless to rancid	Valued by Acid Higher the Tit the better the '
MUTTON TALLOW	Fat of Sheep	Same	White	Fairly pleasant	Tasteless to strong	Inferior to Beef'
BUTTER FAT From Cow's Milk	Fat of Cow's Milk	Churning of Cream of Cow's Milk	Colorless to light yellow	Characteristic	Characteristic	

	GLYCERIDES.	CHARACTERISTIC TESTS.	ADULTERANTS.	USE.	OTHER OILS OF GROUP.
	Stearic Small amt. { Palmitic { Oleic		None	Eating [and Butter To adulterate Lard Soap stock	**SOLID FATS.** **Vegetable.**
no aper	Palmitic Oleic		None, save water and dirt	Candle stock Soap stock	Chaulmoogra Oil Carapa (Crab Wood) Oil
= ongo Free heat,	Palmitic Oleic			Candle stock Soap stock Cover hot iron before tin-dipping	Laurel Oil Mowrah-seed Oil (or Mahwah Butter) Shea (Galam) Butter Macassar Oil Sawarri Fat Mafura Tallow Dika (Oba) Oil
	Stearic Palmitic Lauric, etc. (?)		Beeswax Paraffin Wax Tallow Almond Arachis Sesame Cocoanut	Eating [and Butter To adulterate Lard Soap stock	Ucuhuba Fat Malabar (Piney) Tallow Nutmeg Butter Borneo Tallow
eces- aking	26% Oleic 33% Stearic, Palmitic, Myristic 40% Lauric, Capric, Caprylic, Caproic	Like Cocoanut High sapon. value Reichert-Meissl value	None Cocoanut	Soap stock Artificial Butter	
asily ancid	Like Palm-nut Oil	Like Palm-nut Oil	None Palm-nut	Eating Soap stock Candle stock Artificial Butter	
swax	Stearic Palmitic Myristic Oleic (trace)			Candle stock Hottentots eat wax like cheese	
	Palmitic Stearic (trace) Arachidic and free Palmitic Acid	Ease of saponification Small ash (0.02–0.08%)	Water	Candle stock [wax To adulterate Bees- Polish woodwork To make wax matches	
	Palmitic Stearic Oleic			Eating Adulterate higher-cost Fats	**Animal.**
	Palmitic Stearic Oleic				
	Palmitic Stearic Oleic	Depends on adulterant	Beef Tallow Cotton-seed Oil and Stearin Arachis, Sesame Maize, Cocoanut	Eating Lard Oil	
	Palmitic Stearic			Pharmacy Pomade	
	Palmitic Stearic Oleic Impurities of calcium salts from bones			Candle stock	
alue test llow	Palmitic Stearic Oleic	Depends on adulterant	Resin, Resin Oil Paraffin Wax Palm-nut Oil Cocoanut Oil Cotton-seed Oil and Stearin	Candle stock Soap stock Lubricating Butter substitutes Tallow Oil	
llow	Palmitic Stearic Oleic			Same, but inferior, and becomes rancid easier	
	Butyric Caproic, Capric, Caprylic Palmitic, Stearic, Myristic, Oleic	Reichert-Meissl, Hehner, sapon. values	Lard, Tallow, Fats Cotton-seed Stearin [nut Oil Cocoanut Oil, Palm-	Eating	

SOLUBILITY OF THE OILS, FATS, AND WAXES.—TABLE I.

	Water.	Alcohol—cold.	Alcohol—hot.	Ether.
Oils, Fats, Waxes	All insoluble	Almost all insoluble	More soluble than in cold	All soluble
Exceptions		Very soluble Castor Croton Olive kernel Fairly soluble Cocoanut Oil Palm-nut Oil Porpoise Oil Oils of Glycerides of Linoleic Acid, as Linseed Oil Slightly soluble Wool Fat Beeswax Insect Wax		Sparingly soluble Stearin Insect Wax

	Carbon Bisulphide.	Chloroform.	Benzol.	Mineral Oil.	Petroleum Ether.
Oils, Fats, Waxes	All soluble	All soluble	All soluble	All soluble	All soluble
Exceptions				Insoluble Castor	Insoluble Castor

ADULTERATION OF THE OILS, FATS, AND WAXES.

This table is made with the object of giving an intimation of the probable adulterants, depending on market price. Oils of one class are adulterated by the cheaper ones of that class.

All adulterants must be cheaper than the oil itself. Oils are adulterated with cheaper oils of any and all classes. General Adulterants = Mineral Oils and Resin Oils (in table implied under each oil).

CLASS.	OILS, ETC.	ADULTERATED WITH	ADULTERANT IN
VEGETABLE OILS. Drying.	LINSEED	Rape Oils Cotton-seed Oils Fish Oils	Walnut Rape Castor Olive
	HEMP-SEED	Same	Linseed Rape Olive
	WALNUT	Same, and Linseed Sesame Arachis	Olive
	POPPY-SEED	Same	Olive Sesame Arachis Linseed Rape, Olive
Semi-drying.	MAIZE		Drying Oils Lard Olive Lard Oil
	COTTON-SEED	Linseed (?)	*General Adulterant.* Olive, Lard, Butter Drying Oils Sesame, Rape, Arachis Neat's-foot
	SESAME	Poppy-seed Arachis Cotton-seed Rape	Drying Oils Arachis, Olive Lard Oil Lard Cocoa Butter
	RAPE	Drying Oils Cotton-seed Hedge Mustard Fish Oils	Drying Oils Sesame Castor Olive Neat's-foot
	CROTON	Castor	
	CASTOR	Drying Oils Rape Oils Cotton-seed	Croton Olive

Oil, Fat, or Wax.	Water.	Ether.	Chloroform	Carbon Bisulphide.	Carbon Tetra-chloride.	Petroleum Ether.	Mineral Oils.	1000 dis at Gr
Linseed	Insol.	Sol.	Sol.	Sol.	Sol.	Sol.	Sol.	70
Hemp-seed	"	"	"	"	"	"	"	53
Walnut	"	"	"	"	"	"	"	44
Poppy-seed	"	"	"	"	"	"	"	47
Maize	"	"	"	"	"	"	"	
Cotton-seed	"	"	"	"	"	"	"	64
Sesame	"	"	"	"	"	"	"	41
Rape	"	"	"	"	"	"	"	15 to
Croton	"	"	"	"	"	"	"	
Castor	"	"	"	"	"	Insol.	Insol.	
Arachis	"	"	"	"	"	Sol.	Sol.	66
Olive	"	"	"	"	"	"	"	36
Olive Kernel	"	"	"	"	"	"	"	
Menhaden	"	"	"	"	"	"	"	
Sardine	"	"	"	"	"	"	"	
Cod Liver	"	"	"	"	"	"	"	
Seal	"	"	"	"	"	"	"	
Whale	"	"	"	"	"	"	"	
Dolphin	"	"	"	"	"	"	"	
Porpoise	"	"	"	"	"	"	"	
Neat's Foot	"	"	"	"	"	"	"	
Sheep's Foot	"	"	"	"	"	"	"	
Horse's Foot	"	"	"	"	"	"	"	
Lard Oil	"	"	"	"	"	"	"	
Tallow Oil	"	"	"	"	"	"	"	
Cotton-seed Stearin	"	"	"	"	"	"	"	
Vegetable Tallow	"	"	"	"	"	"	"	
Palm Oil	"	"	"	"	"	"	"	
Cocoa Butter	"	"	"	"	"	"	"	
Palmnut Oil	"	"	"	"	"	"	"	
Cocoanut Oil	"	"	"	"	"	"	"	
Myrtle Wax	"	"	"	"	"	"	"	
Japan Wax	"	"	"	"	"	"	"	
Horse Fat	"	"	"	"	"	"	"	
Goose Fat	"	"	"	"	"	"	"	
Lard	"	"	"	"	"	"	"	
Beef Marrow	"	"	"	"	"	"	"	
Bone Fat	"	"	"	"	"	"	"	
Beef Tallow	"	"	"	"	"	"	"	
Mutton Tallow	"	"	"	"	"	"	"	
Butter Fat	"	"	"	"	"	"	"	
Sperm Oil	"	"	"	"	"	"	"	
Arctic Sperm Oil	"	"	"	"	"	"	"	
Carnaüba Wax	"	"	"	"	"	"	"	
Wool Fat	"	"	"	"	"	"	"	
Beeswax	"	"	"	"	"	"	"	
Spermaceti, Cetin	"	"	"	"	"	"	"	
Insect Wax, China Wax	"	Slightly sol	"	"	"	"	"	

…bsolute Alcohol.		Acetic Acid. Sp. gr. 1.0565 at 15° C. Jean.	Acetic Acid. Temperature of turbidity for equal volumes of Oil and Acetic Acid. Sp. gr. 1.0562.			Glacial Acetic Acid.	Benzol.
…ms. …ve …C. …D.	Pure.		Valenta.	Allen.	Hurst.		
	Oil:Alc.						
…ams	1 : 5 Moerck			57° to 74° C.	36° to 41° C.		Sol.
"	1 : 30 "						"
"	1 : 188 "	36.60%					"
		Indies 63.30%					
"	1 : 25 "	French 43.30					"
	1 : 50 Smith	100.70%				3 : 100 Smith	"
"			110° C.	90° C.	53°, 63° C.		"
"			107° C.	87° C.			"
…0 gr		30 to 33.30%	Insol.	Insol.	73° to 99° C.		"
	Miscible in all proportions					Miscible in all proportions	"
	Miscible in all proportions	100.00%				Miscible in all proportions	"
…ams		Boulam 41.65% Gambia 43.66	112° C.	87° C.	72° to 92° C.		"
"	3.6 : 100 Moerck	35%	Yellow, 111° C Green, 85° C		28° to 76° C.		"
	More soluble than Olive					Miscible in all proportions	"
				64° C.			"
							"
			101° C.	79° C.	65° C.		"
				72° C.	34° C.		"
				36° to 38° C.	48° to 71° C.		"
							"
	Jaw sol. at 70° C. Body insol. at 70° C.			40° C.	74° to 84° C.		"
		43.3%		100° C.	65° to 85° C.		"
		36.66%					"
							"
					69° to 76° C.		"
					47° C.		"
		40%					"
							"
		100%	23° C.	83° C.			"
			105° C.	Insol.			"
	1 : 2 (90%) at 60° C.		48° C.	32° C.			"
	1 : 2 (90%) at 60° C.	100%	40° C.	7.5° C.			"
							"
	Insol.						"
		30%					"
							"
		26.66%		96.5%			100 grms. at 12° C. dissolves, Dubois & Padé 27.30
			90° to 95° C.				
			95° C.				15.89
							14.70
		63.33%		61.5° C.			09.61
	Insol.			98° to 103° C.	85° C.		Sol.
	Insol.						"
	Insol.						"
	Slightly sol.						"
	Nearly insol.						"
	Insol. in 90%						
	Nearly insol. in 96%						"
	Slightly sol.						Very sol.

ADULTERATION OF THE OILS, FATS, AND WAXES—*Continued.*

CLASS.	OILS, ETC.	ADULTERATED WITH	ADULTERANT IN
VEGETABLE OILS. Non-drying.	ARACHIS	Poppy-seed Sesame Cotton-seed	Walnut Sesame Olive Cocoa Butter Lard
	OLIVE	Drying Oils Cotton-seed, Arachis Sesame, Rape Castor, Curcas, Lard Oil, Fish Oils	
	OLIVE-KERNEL		
ANIMAL OILS. Marine.	MENHADEN		Drying Oils Rape Olive Sperm
	SARDINE	Cheap Fish Oils	Same
	COD-LIVER	Fish Oils Vegetable Oils	Olive Sperm
	SEAL		Drying Oils Whale Sperm Rape Olive
	WHALE	Seal Oil	Drying Oils Rape Olive Sperm
	DOLPHIN		Same
	PORPOISE		Same
Terrestrial.	NEAT'S-FOOT	Fish Oils Rape Cotton-seed Poppy-seed Oils of this class	
	SHEEP'S-FOOT		Neat's-foot
	HORSE-FOOT		Neat's-foot
	LARD OIL	Cotton-seed Sesame Maize	Neat's-foot Olive
	TALLOW OIL		Neat's-foot

ADULTERATION OF THE OILS, FATS, AND WAXES—*Continued.*

CLASS.	OILS, ETC.	ADULTERATED WITH	ADULTERANT IN
SOLID FATS. **Vegetable.**	Cotton-seed Stearin		Lard Butter Tallow Sperm Oil
	Vegetable Tallow		
	Palm Oil		Sperm Oil
	Cocoa Butter	Beeswax Tallow Almond Oil Arachis Sesame Cocoanut Oil	
	Palm-nut Oil		Beef Tallow Butter Lard Sperm Oil
	Cocoanut Oil		Cocoa Butter Lard Beef Tallow Butter Sperm Oil
	Myrtle Wax		
	Japan Wax		Beeswax
Animal.	Horse Fat		High cost Fats, as Butter
	Goose Fat		Same
	Lard	Beef Tallow Cotton-seed Oil and Stearin Arachis Sesame Maize Cocoanut	Butter
	Beef Marrow		
	Bone Fat		
	Beef Tallow	Palm-nut Oil Cocoanut Oil Cotton-seed Oil and Stearin	Cocoa Butter Lard Butter Beeswax Spermaceti

ADULTERATION OF THE OILS, FATS, AND WAXES—*Continued.*

CLASS.	OILS, ETC.	ADULTERATED WITH	ADULTERANT IN
SOLID FATS. Animal.	Mutton Tallow		Cocoa Butter Butter Beeswax Spermaceti
	Butter Fat	Lard, Tallow Goose Fat, Horse Fat Cotton-seed Stearin Cocoanut Oil Palm-nut Oil	
WAXES. Liquid.	Sperm Oil	All Fish Oils Vegetable Solid Fats Arctic Sperm Oil	
	Arctic Sperm Oil		Sperm Oil
Solid. Vegetable.	Carnaüba Wax	Stearin Cerasin Paraffin Wax	Beeswax
Solid. Animal.	Wool Fat		
	Beeswax	Tallow Stearin Japan Wax Myrtle Wax Insect Wax Carnaüba Wax Cerasin Paraffin Wax	Spermaceti Cocoa Butter
	Spermaceti	Beeswax Tallow Stearin Cerasin Paraffin Wax	
	Insect Wax		Beeswax (?)

CHAPTER II.

PHYSICAL EXAMINATION OF THE OILS, FATS, AND WAXES.

SPECIFIC GRAVITY.

It seems unnecessary in a book intended for oil-chemists who have had a chemical education to go into the details of finding the specific gravity; hence only suggestions will be offered here.

Liquids.

Hydrometer.—This should be used only for rapid work where absolute accuracy is not required.

Picnometer.—This gives the greatest degree of accuracy. There are many kinds, among which may be mentioned as especially adapted for this work Sprengel's U tube.

Mohr-Westphal Hydrostatic Balance.—This gives fairly accurate results and is more rapid in its manipulation than the picnometer.

Solids.

Picnometer of Gintl can be conveniently used with good results.

Reference: Dingl. Polyt. Jour. 194, p. 42.

Various other methods for liquid and solid oils, fats, and waxes can be found in oil books of reference and research by various authors.

Cf. J. S. C. I., 1883, p. 54; 1886, p. 65.

Analyst, V. p. 76.

VISCOSITY.

Viscosity bears no relation to the density of liquids, but is internal friction. It might be said to be the ease of flow of an oil. Pure rape oil is the usual standard; viscosity is relative.

Ordinary Technical Method.—Allow the oil to run out of a pipette at a definite temperature, and determine the number of seconds required for emptying the pipette. A similar test is made with olive oil (preferably rape oil) as a standard, which is taken as 100.

The proportional number of seconds required for the tested oil gives the desired viscosity.

Penn. R.R. Co. Method.—A 100-c.c. long-bulb pipette is regraduated so as to hold just 100 c.c. to the bottom of the bulb. The size of the aperture at the bottom of the pipette is so made that 100 c.c. of water at 100° F. will run out of the pipette in 34 seconds. Pipettes with bulbs varying from 1⅝–1⅛ inches outside diameter give almost exactly this result. The oil is heated to the required temperature (care being taken that it is uniformly heated) and is then drawn up into the pipette to the required mark. The time taken by the oil to run out of the pipette to the bottom of the bulb gives the test figure.

These pipettes are known as the Penn. R.R. Viscosity Pipette.

More accurate methods of determining viscosity can be found in the following references:

COLCAN, J. S. C. I., 1886, p. 359.
REDWOOD, " 1886, p. 127. Adopted by Scotch Min. Oil Assn.
" (Allen's Mod.), 1886, p. 131.
SCHMID'S REISHAUSER VIS., Chem. Zeit., 1885, p. 1514.
ENGLER, J. S. C. I., 1893, p. 292. Used in Europe.
ENGLER and KÜNKLER, " 1890, p. 654.

No constants are given here, because they are of no avail unless accompanied by the method.

OPTICAL REFRACTION—ROTATORY POWER—MICROSCOPICAL APPEARANCE—ELECTRICAL CONDUCTIVITY—SPECTROSCOPICAL EXAMINATION.

These five subjects are dealt with in works of wider scope than this and are too extensive to be considered in a handbook intended for the ordinary oil laboratory. The apparatus is expensive and would not be found in a laboratory unless special research was being carried on.

MELTING POINT AND SOLIDIFYING POINT.

The results are poor and do not agree; a good accurate method is still to be found. It has not yet been decided whether a fat melts at the temperature at which it softens or when it becomes transparent.

Melting point is the opposite of solidifying point, and is so determined.

Penn. R.R. Co. Method.—Of commercial value only. 50 c.c. of the oil or fat is placed in a 100-c.c. bottle, and a thermometer is placed in the oil. The oil or fat is then frozen, using a mixture of ice and salt if necessary. When the oil has become hard the bottle is removed from the freezing mixture, placed on its side, and the oil allowed to soften, being stirred constantly with the thermometer until the oil will run from end to end of the bottle. The reading of the thermometer is then taken.

Prime lard oil should not give a cold test above 13° C.

Pohl's Method, used in Europe.—In this method the temperature is read when the fat just begins to become liquid; and the liquid may contain solid particles.

Into melted fat a thermometer is thrust and withdrawn so that the bulb remains covered with a coating of cooled fat. This coated thermometer is laid aside for a day or so, in order that the fat may regain the same physical structure it had before being melted.

The thermometer is then placed inside of a long wide test-tube with the bulb about ½ inch from the bottom. The test-tube is slowly heated by radiated heat. As soon as a liquid drop of fat forms at the bottom of the thermometer bulb, the temperature is read.

Capillary Tube.—The method is the same as the one used for determining the melting point of organic solids.

The tube is drawn from a thin-wall test-tube and is about 1–2 cm. long and of the smallest possible diameter. This tube is closed at one end and a drop of melted fat is introduced. This solidified fat is allowed to stand 2 or 3 days, and then the tube is attached to a thermometer, with the fat in the tube and the bulb of the thermometer on a level. The thermometer and tube are dipped into a beaker containing a fixed oil or glycerol and this bath is gradually heated. The melting point is noted.

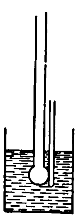


FIG. 1.

Method of Le Sueur and Crossley, J. S. C. I., 1898, p. 988.

THEORY.—Liquids exhibit property of capillarity; solids do not.

METHOD.—In a thin-wall tube (*B*), 75 mm. long by 7 mm. wide, is placed the capillary tube (*C*) open at both ends. The tube (*B*) is attached to the thermometer (*A*).

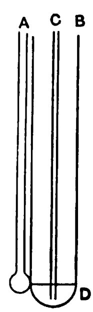


FIG. 2.

The fat is introduced into (*B*) as (*D*), and the capillary tube dips into the fat. The whole is dipped into cold water which

is slowly heated. The temperature at which the fat begins to rise in the capillary tube (C) is taken as the melting point.

Other methods:

WILEY, U. S. Depart. Agr. Bulletin No. 13, p. 439.
BENSEMANN, J. S. C. I., 1885, p. 535.
CHRISTOMANUS, " 1890, p. 894.

Solidifying Point of Fatty Acids.—See *Titer Test.*

CHAPTER III.

CHEMICAL EXAMINATION OF THE OILS, FATS, AND WAXES.

MAUMENÉ TEST.

RISE IN TEMPERATURE—SPECIFIC TEMPERATURE REACTION.

THEORY.—Drying oils + H_2SO_4 (conc.) = higher temperature.
Non-drying oils + H_2SO_4 (conc.) = lower "

Reference: Original method Maumené, Compt. Rendus, 1882, p. 572.

It must be noted that for this test the conditions and acid must be the same to give reliable results.

METHOD.—Reference: THOMSON & BALLANTYNE, J. S. C. I., 1891, p. 233.

APPARATUS.—One 150-c.c. tall-formed beaker is placed in a beaker two sizes larger, and the space between is packed with cotton.

One 10-c.c. pipette, delivering 10 c.c. in 1 minute.

One centigrade thermometer.

Sulphuric acid (sp. gr. 1.83).

50 c.c. of distilled water are placed in the beaker, and the beaker and the bottle of H_2SO_4 are cooled by water to 20° C. The beaker is wiped dry and placed in the outer beaker with cotton.

10 c.c. of H_2SO_4 are then drawn up into the pipette and the acid allowed to run into the water while the latter is being stirred vigorously with the thermometer. The maximum temperature is noted. This should be repeated several times for use as a constant.

5.0 grams of oil are weighed into the above beaker, after it has been dried of the water it contained, and the oil is treated exactly as the water has been.

The maximum temperature is the Maumené Value.

The Specific Temperature Reaction Value is obtained by dividing the Maumené Value of the oil by the rise in temperature of the water.

This is the *Specific Temperature Reaction* compared with water taken as unity.

Errors due to lack of uniformity in apparatus, acid, rapidity of flow, etc., are less in the Specific Temperature Reaction than in the Maumené Value.

If the oils are oxidized, it is best to test the fatty acids, or treat the oil with alcohol before testing.

Light and air increase the Maumené Value, because of the oxidation of the oil.

The author can give the following results:

Oil.	Maumené.	Spec. Temp. Reaction.
Water	46.5	1.00
Olive Oil	44.0	0.95
Rape	58.0	1.24
Castor	42.0	0.91
Linseed	125.2	2.69
Cotton-seed	79.0	1.69

Thomson & Ballantyne give the following table:

Oil.	Spec. Temp. Reaction. Water = 1.	Oil.	Spec. Temp. Reaction. Water = 1.
Olive, Candia	0.92	Linseed, Baltic	3.49
Gioga	0.89	E. India	3.20
Levant	0.90	River Platte	3.20
Malaga	0.90	Castor, comm.	0.89
Mogador	0.93	Sperm, Southern	1.00
Mitylene	0.92	Arctic Sperm	0.93
Syrian	0.92	Whale, pale	1.57
Cooking	0.92	Seal, cold-drawn pale	2.25
Cotton-seed, crude Egypt.	1.63	steam- " "	2.12
refined	1.70	tinged	2.29
	1.69	Norwegian	2.23
Rape	1.27	Cod, Newfoundland	2.43
	1.35	Scotch	2.46
	1.44	Cod-liver, medicinal	2.72
	1.33	Menhaden	3.06
Arachis, comm	1.37		
French refined	1.05		

Reference: Method of ARCHBUTT similar to Thomson & Ballantyne.

ALLEN, similar to Thomson & Ballantyne, excepting in stirring. Allen's Commer. Org. Anal.

ELLIS, J. S. C. I., 1886, pp. 150, 361.

JEAN, Thermelacometer, J. S. C. I., 1890, p. 113.

POUTET'S ELAIDIN TEST.

THEORY.—Oleic acid $+ HNO_2$ $=$ solid elaidic acid,

$$
\begin{array}{r}
C_8H_{17}\text{–}C\text{–}H \\
\| \phantom{\text{–}H} \\
H\text{–}O\text{–}O\text{–}C\text{–}(CH_2)_7\text{–}C\text{–}H
\end{array}
$$

$$
\left.\begin{array}{l}\text{Linoleic} \\ \text{Linolenic} \\ \text{Isolinolenic}\end{array}\right\} + HNO_2 = \text{liquid.}
$$

Drying oils $+ HNO_2 =$ liquid mass.
Semi-drying oils $+ HNO_2 =$ buttery mass.
Non-drying oils $+ HNO_2 =$ solid mass.

Olive oil and other non-drying oils possess the property of being converted into solid isomeric modifications under the influence of nitrous acid. This property was first applied to the detection of adulterants in olive oil by Poutet in 1818.

Oils grouped by Allen according to this test:

(1) Solid hard mass: olive, almond, arachis, lard oil, sperm oil, sometimes neat's-foot oil..

(2) Butter-like mass: neat's-foot, arctic sperm, mustard-seed, sometimes arachis, sperm, rape.

(3) Pasty or buttery mass separating from a fluid portion: rape, sesame, cotton-seed, sunflower, Niger-seed, cod-liver, seal, whale, porpoise.

(4) Liquid: linseed, hemp-seed, walnut, poppy-seed, and all drying oils.

Hardest elaïdin given by olive, arachis, and lard oil, and is a special test for olive oil.

REAGENTS.—Nitric acid (sp. gr. 1.42).
Mercury (or copper).

Elaïdin or nitrous acid reagent for test.

18.0 grams of mercury are placed in a dry stoppered 50-c.c. bottle, and 15 c.c. of nitric acid (sp. gr. 1.42) are added. Action at once begins, but there is no escape of gas; the nitrous acid formed by the reaction being absorbed with the production of a deep green color. After a time the bottle is placed in water (10° C.) and the stopper inserted into the bottle. In 5–10 minutes the mercury has disappeared and a deep green liquid remains with some white solid at the bottom.

The stopper is cautiously removed, and the white deposit (if considerable) is dissolved up by careful stirring and, if necessary, by the application of a very gentle heat.

This solution is good for use as long as it remains a deep green color.

Keep the reagent in the dark.

METHOD.—Reference: ARCHBUTT, J. S. C. I., 1886, p. 306.

0.96 grams of the oil are weighed into a wide-mouth stopper-bottle and 3.25 c.c. of the elaïdin reagent is run into it from a burette. The whole is then shaken and placed in water of 10° C. Shake at intervais of 10 minutes until solidification takes place or until further shaking is considered unnecessary.

Oil.	Minutes required for Solidification at 10° C.	After 24 Hours at 10° C.	
		Color.	Consistency.
Olive	60	Yellow	Impenetrable to glass
Oleic acid	50	"	Easily penetrated [rod
Walnut (best)	60–90	Lemon	Soft
Neat's-foot	180	"	Barely penetrable
Rape, refined	Over 6 hrs.	Orange	Apparently solid
Arctic sperm	160	Lemon	Soft
Sperm (old)	Thick in 6 hrs.	Orange	Buttery
Cotton-seed	...	"	Thin fluid
Niger-seed	...	"	" "
Cod-liver	...	Blood-red	Fluid with sediment
Castor	...	...	No change
Sesame	...	Orange	Thick fluid
Menhaden	...	Dark red	" "

A simple way of making the test is to add to 9 volumes of oil in a test-tube 1 vol. HNO_3 (sp. gr. 1.42) and a little mercury or copper. After gas has been generated some little time, stir and allow to stand.

Action of H_2SO_4 upon elaidic acid, Tscherbakoff and Saytzeff, J. S. C. I., 1898, p. 359.

LIVACHE'S OXYGEN TEST.

THEORY.—More rapid drying of a drying oil than takes place under ordinary circumstances by exposing more surface to the atmosphere.

Drying Oils: The better the drying property of the oil the higher the amount of oxygen absorbed.

Drying oil + O_2 = maximum absorption after 18 hours (some 3 days).

Non-drying oils + O_2 = gain no weight before 4–5 days.

Free fatty acids (excepting those of cotton-seed) act like the glycerides. Drying oils appear to show their drying property in proportion to the amount of linoleic and linolenic acids contained.

REAGENT.—*Lead Powder:* This is made by precipitating the lead from a lead salt by the use of zinc. The precipitate is washed rapidly with (1) water, (2) alcohol, and (3) ether, and is then dried in vacuum.

METHOD.—LIVACHE, J. S. C. I., 1886, p. 494.

Weigh onto a watch-glass 1.0 gram of lead powder, spread out into a thin layer. Drop from a pipette onto this powder about 0.6 gram of the oil to be tested, taking care that the drops do not run together.

Allow the watch-glass to stand exposed to light at the temperature of the room.

Gain in weight = Livache Value.

Oil.	Gain in Weight of 100 Parts.				Observer.
	Of Oil after			Of Fatty Acids after	
	2 Days.	3 Days.	7 Days.	8 Days.	
Linseed	14.3			11.0	Livache
Walnut	7.9			6.0	"
Poppy-seed	6.8			3.7	"
Cotton-seed	5.9			0.8	"
Beech nut	4.3			2.6	"
Colza (Rape)			2.9	2.6	"
Rape			2.9	0.9	"
Sesame			2.4	2.0	"
Arachis			1.8	1.3	"
Olive			1.7	0.7	"
Whale		8.266			Jean
Japanese Sardine		8.194			"
Cod-liver		6.383			"
Menhaden		5.454			"
Sperm		1.629			"

References: KISSLING, J. S. C. I., 1891, p. 778.
FAHRION, 1894, p. 405.

WARREN'S SULPHUR CHLORIDE TEST.

The test, as it exists to-day, is of no great value when compared to the other tests for the chemical examination of an oil.

The claim made for the test is that drying oils treated with sulphur chloride yield solid masses insoluble in carbon bisulphide, whereas non-drying oils give a mass soluble in carbon bisulphide.

References: WELLEMANN, J. S. C. I., 1891, p. 800.
WEBER, " 1894, p. 11
HENRIQUES, " 1894, p. 47.

COLOR TESTS, given for the detection of certain oils, have proven of so little value that they are omitted from this work, with a few exceptions which are the most noteworthy. Among these, however, Becchi's test does not prove definitely the presence or absence of cotton-seed oil; and so, with the few given, they drop into mere indications of no very great value.

The results of color tests should always be accepted with very great caution.

BECCHI'S SILVER NITRATE TEST.

(Analyst, Sept., 1887.)

Cotton-seed oil = brown color.

$$\left.\begin{array}{l}\text{Olive oil}\\ \text{Lard (slight color)}\\ \text{Lard oil}\end{array}\right\} = \text{no color.}$$

The test is fairly good.

Cotton-seed oil to give this test must be fairly fresh and must not have been heated to 240° C.

REAGENTS.—A. 1.0 gram silver nitrate dissolved in 200 c.c. of absolute alcohol and 40 c.c. ether (c. p.); add 0.1 gram HNO_3.

B. 0.1 gram silver nitrate dissolved in 200 c.c. alcohol and ether; add 0.1 gram HNO_3.

C. 15 c.c. cold-drawn filtered colza oil in 100 c.c. amyl alcohol.

The colza oil should be filtered two or three times through paper placed in a hot filter.

The alcohol and ether must be absolutely chemically pure.

When 1 c.c. of solution A or 10 c.c. of solution B are heated for a quarter of an hour in a steam-bath, they should retain their color.

METHOD.—10 c.c. of the oil and 1 c.c. of solution A (or 10 c.c. of solution B) and 10 c.c. of solution C are placed in a test-tube and well agitated. Half of this mixture is poured into a test-tube and kept as a standard of comparison.

The remainder of the mixture is then heated on a steam-bath for 15 minutes and the color noticed.

Pure olive oil should not take on a brown color.

Cotton-seed, cotton-seed and olive oils, and cotton-seed mixtures change rapidly to a red-brown.

Modifications: PATTINSON, J. S. C. I., 1889, p. 30.
WESSON, J. Chem. Soc., 1894, Abst. II, p. 75.
J. SUISSE, de Chim. et Pharm., J.S.C.I., 1898, p. 76.

REAGENT.—1.0 gram of silver nitrate is dissolved in 5 c.c. of water and mixed with: alcohol, 200 c.c.; ether, 20 c.c.; nitric acid (1:40), 1 c.c.

Application: 10 c.c. of the oil or fat and 3 c.c. of the reagent are heated in a test-tube on a water-bath for 10 minutes.

Brown or black color indicates cotton-seed oil.

BAUDOUIN'S TEST.

Sesame oil + test = red color.

REAGENTS.—Sugar + hydrochloric acid.

In a test-tube dissolve 1.0 gram of sugar in 10 c.c. hydrochloric acid (sp. gr. 1.19). To this add 20 c.c. of the oil to be tested and shake 1 minute. Red color indicates sesame oil.

This test was found to take place with olive oils, and so was of no especial value. These modifications are found to be superior to the original test.

Modifications. *Tocher's Test* gives negative results with olive oil, and hence of value (A. J. F. da Silva, J. S. C. I., 1898, p. 276).

15 grams of oil are shaken with an equal weight of a solution of 2 grams of pyrogallol in 30 grams of hydrochloric acid, and, after being left for some time, the oily layer is decanted and the hydrochloric acid is warmed 5 minutes.

Reddish-purple color indicates sesame oil.

VILLAVECCHIA & FABRIS, J. S. C. I., 1891, p. 69.
1898, p. 76.
1899, p. 790.

REAGENT.—2 grams furfuraldehyde in 100 c.c. of alcohol. (Furfurol itself gives a violet color with hydrochloric acid; so a very weak solution of furfurol is essential.)

Application: 10 c.c. of the oil are agitated thoroughly for ½ a minute with 0.1 c.c. of the reagent and 10 c.c. of hydrochloric acid (sp. gr. 1.19).

Red color indicates sesame oil.

CHAPTER IV.

ANALYSIS OF THE OILS, FATS, AND WAXES.

Purification of the Sample.—Before the weighing of the oil or fat for the determination of constants, but not before the determination of moisture, fat, and foreign matter, the oil or fat should be purified.

This is done by filtration.

A thin oil can be filtered directly through a cotton filter.

A thick oil or fat can be filtered through a hot filter such as is shown in the figure.

This hot filter consists of a copper jacket the edges of which are curled back so that the condensed water will not run into the funnel or into the filtered fat. The copper jacket is fitted with a glass funnel which is inserted into a rubber stopper (*A*), and this in turn fits the bottom of the jacket. The funnel is fitted out with an absorbent

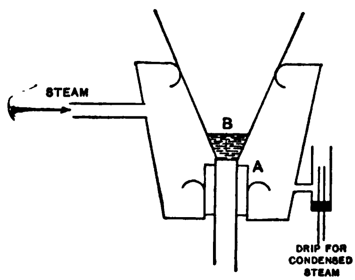


FIG. 3.

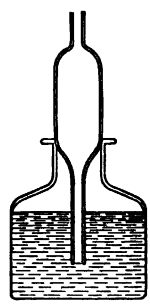


FIG. 4.

cotton wad (*B*). Steam conducted into this jacket heats the fat inside the glass funnel and allows it to filter through the cotton wad.

Weighing of the Sample.—For liquid glycerides and waxes, after having been thoroughly mixed, it is preferable to weigh a large amount, say 25.00 grams, in a weighing-bottle or beaker.

Take out the charge and reweigh the bottle. The loss in weight will give the charge. For drawing out the charge a 5–10-c.c. pipette

can be most conveniently used. The diameter of the aperture of the pipette must be such as to allow a free flow of oil. The bottle of oil and the pipette are weighed together when the oil is to be weighed out; in this way there will be no loss from dripping, and the pipette acts to a certain extent as a stopper if the weighing-bottle is selected so that the bulb of the pipette just fits the diameter of the neck of the bottle.

When solid glycerides or waxes are to be weighed, they should be heated to melting and thoroughly mixed, and then taken from the weighing-bottle. Of course the bottle and contents should be cooled in a desiccator before weighing.

MOISTURE.

Method of Sonnenschein, J. S. C. I., 1886, p. 508.

Hopkins-Coburn Modification.—Many methods of drying oils and fats, tried in the laboratory of the author, have proved very unsatisfactory because of tediousness and lack of concordant results; hence we have devised the following:

A test-tube of 60–80 mm. in length and 15–20 mm. in diameter is used, with a small hole blown in its bottom at (*e*), and furnished

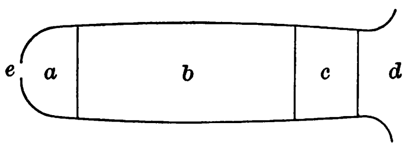


FIG. 5.

with a platinum wire around the lip at (*d*) for suspending the tube while weighing. A small wad of absorbent cotton is first inserted into the tube (as *a*), then an ashless filter-paper of 12 cm. diameter is folded about the finger (placing the tip of the finger in the centre of the paper) and is placed in the test-tube so that, upon withdrawing the finger from the inside of the filter-paper, the paper, with its closed end on the cotton wad (*a*), takes the shape of the test-tube and forms a filter-paper capsule which prevents the solid matter of the oil from being mechanically carried through the cotton. Because of its size and lightness this filter-paper is preferred to a regular Soxhlet cartridge.

The inside of this filter-paper capsule (*b*) is filled with closely rolled ashless filter-paper, and a cotton wad is put on top (*c*). This test-tube (so filled) is dried and weighed for tare. The upper wad is then removed and the oil introduced and absorbed by the filter-paper, care

being taken that the oil does not saturate the cotton wad at (*a*). The upper wad (*c*) is then replaced and the weight taken. The test-tube is then dried in a water-jacket oven, so that the temperature is sure to remain constant at 100° C. Hot air is drawn through the test-tube containing the oil. This is done under a gentle suction from the filter-pump. A cheap and convenient form of apparatus for this purpose is shown in Fig. 6. The apparatus consists of a Y tube upon the two arms of which are two rubber stoppers (*G*), and on these a large-diameter rubber connection-tube (*H*) to fit the test-tube containing the oil. The hot oven-air is drawn from *d*, through the test-tube, out *e*, and up the Y tube to the pump. This form of apparatus allows two samples to run under exactly the same conditions and can easily be placed in the water-oven.

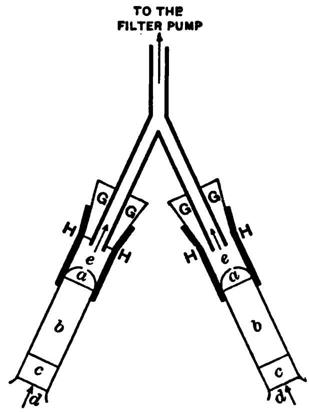


FIG. 6.

When compared with other methods tried by us, this proved to be far more satisfactory in rapidity and closeness of results. Loss in weight gives the moisture.

When an oil is to be dried which will oxidize under the above conditions a generation of CO_2 or H_2 or illuminating-gas may be attached at *d* and so prevent this oxidation. This method also does away with specially constructed air-tight ovens for desired atmospheres of certain gases.

After moisture has been determined, the residue should be retained to determine the fat and foreign matter.

FATTY AND NON-FATTY FOREIGN MATTER.

All oils and fats are soluble in petroleum ether excepting castor oil.

After the moisture has been determined, place the weighed test-tube in a soxhlet and extract the fat with petroleum ether (pentane 40° preferred). The soxhlet must have a shorter siphon-tube than is customary. A siphon-tube of 2 inches, rather than the regular 4-inch, is suggested because it just about reaches to the top of the 60–80-mm. test-tube as it sets in the soxhlet. If the siphon-tube is higher than the test-tube, the test-tube is "drawn" and foreign matter is mechanically carried off with the fat. Petroleum ether is preferable to chloroform and benzol because it dissolves less resinous bodies than the latter two.

As a result: Petroleum ether extract = fat soluble.

The residue = soap, dirt, remnants of animal and vegetable tissue.

The residue is treated under the next heading.

Non-fatty Foreign Matter.—The residue left in the test-tube after the fat has been extracted by petroleum ether is again returned to the soxhlet and extracted with alcohol.

Alcohol dissolves soaps, resin, etc.

The residue is again extracted with water, which yields some soluble inorganic salts. Or,

The residue, without treatment with water, is ignited.

Loss in weight = organic matter (hide fragments in case of sod oil).

Weight = ash of inorganic substances.

Ash.—Qualitative and quantitative analysis of this may be made, if desired, according to the ordinary methods of inorganic chemistry.

For these determinations of an ash of an oil or fat the author prefers an ignition of the original sample.

The ash mentioned under "Non-fatty Foreign Matter" is more for a weight; the difference between which and the weight of the residue, left after extraction with alcohol, gives the organic impurities.

THE ACID VALUE (FREE FATTY ACIDS)

represents the number of milligrams of KOH required to neutralize the free fatty acids in 1.0 gram of an oil or a fat.

METHOD.—Dissolve the oil or fat in hot methyl alcohol (which gives a neutral reaction), and titrate the free fatty acids with standard alkali, using phenolphthalein as indicator.

Method.—Holde, J. S. C. I., 1890, p. 113.

2–3 grams of oil are dissolved in a mixture of 20 c.c. ether and 12 c.c. alcohol (which are absolutely neutral).

A few drops of phenolphthalein are added, and $\frac{N}{10}$ alcoholic (50%) solution of KOH is run into the oil until a pink color is obtained. Where the oil is too dark to allow the pink color to be seen Holde suggests the use of a cylinder of about 4 cm. diameter instead of a flask. The author has obtained good results by shaking the oil so that the foam is thrown up. A drop of phenolphthalein on this white foam shows the change of color.

For dark opaque oils 20 c.c. of oil is shaken with 50 c.c. of absolute alcohol in a stoppered cylinder, and the mixture is allowed to

settle. 25 c.c. of the alcohol is than taken, and 10 c.c. ether is added if the liquid is turbid. Titrate with $\frac{N}{10}$ KOH. If more than 2 c.c. KOH is used, the rest of the alcohol is taken, another 50 c.c. of alcohol added to the oil, and the process is repeated. Here, too, the author prefers the shaking to a white foam as before mentioned.

The free fatty acid is generally calculated as oleic (mol. weight of oleic acid = 282).

$$\frac{\text{c.c. } \frac{N}{10}\text{KOH} \times 0.0282 \times 100}{\text{charge}} = \textit{in terms of oleic acid.}$$

NOTES.—(1) Alcohol and ether can be made neutral by allowing them to stand over Na_2CO_3 and distilling.

(2) To obtain a colorless solution of KOH in alcohol, the alcohol should stand over KOH several days and then be distilled.

Note.—If the oil or fat contains mineral acid, this number must be deducted to give the true acid value.

Total acid value — mineral acid value = true acid value.

Köttstorfer Degree of Acidity is represented by the number of c.c. of $\frac{N}{1}$ KOH required to neutralize 100 grams of oil or fat.

THE MINERAL ACID VALUE

represents the milligrams of KOH required to neutralize the free mineral acid in 1.0 gram of oil or fat.

The charge is boiled out with water, which takes up the free mineral acids. This can be done in a separating-funnel or on a filter. The washing is carried on until the oil is absolutely free of acid. Titrate this wash-water with $\frac{N}{10}$ KOH, using phenolphthalein as indicator.

THE SAPONIFICATION VALUE

(KÖTTSTORFER VALUE—TOTAL ACID VALUE)

represents the number of milligrams KOH required to saponify the total fatty acids in 1.0 gram of oil or fat.

The saponification value is *acid value of free fatty acids.*

REAGENTS.—*Standard HCl* (do not use H_2SO_4, as K_2SO_4 is precipitated).

Alcoholic KOH (standardized)—prepared by dissolving 30 grams KOH in a small amount of water and is made up with alcohol to

1000 c.c. Allow to stand 1 day and then filter. The alcohol used should be purified by standing over KOH for several days and then distilled.

Indicator is phenolphthalein.

1.5–3.0 grams of oil or fat are placed in a 200-c.c. flask, and 25 c.c. of alcoholic potash are added from a burette. Heat on steam-bath (with occasional shaking) for half an hour. Titrate, using phenolphthalein as indicator.

In the case of dark oils where the change of color is hard to see, a violent shaking to throw up a white froth may aid in reading the end point.

With wool fat the saponification is so difficult that it should be boiled for hours, or boiled with double-strength KOH under pressure.

ETHER VALUE

represents the number of milligrams KOH required to saponify the neutral fatty acids in 1.0 gram of oil or fat.

The ether value = saponification value less the acid value.

The ether value is the saponification value if the fat contains no free fatty acids.

SAPONIFICATION EQUIVALENT

represents the number of grams of oil or fat saponified by 56.1 grams of KOH.

$$\text{Saponification value} = \frac{56100}{\text{Sapon. value}}.$$

THE IODINE VALUE
(HÜBL NUMBER)

represents the iodine absorbed by the unsaturated fatty acids in a fat or an oil.

References: HÜBL, J. S. C. I., 1884, p. 641.
WILLIAMS, Analyst, 1889, p. 103.
HÜBL, Ding. Polytech. Jour., 253, p. 281.
8th Annual Congress of Agr. Chemists, 1891, p. 199.

SOLUTIONS.—*Starch Solution.*—Add 6.0 grams of finely powdered starch to 80 c.c. glycerine. Heat to 150° C. for ½ hour, stirring constantly. When cooled to about 90° C., add 150 c.c. salt solution (1 : 10); allow to stand, and filter through a cotton filter.

Iodide Solution.—Dissolve 25 grams of iodine in 500 c.c. of 95% alcohol. Dissolve 30 grams of $HgCl_2$ in 500 c.c. of 95% alcohol. Mix the two and allow to stand. Standardize.

Potassium Iodide Solution.—Dissolve 25 grams KI in 500 c.c. water. As commercial KI often contains KIO_3, which gives free

iodine with HCl, be careful of the purity of the KI used, or make allowance for the iodine liberated.

Sodium Thiosulphate Solution.—Standard solution, 24.8 grams to 1000 c.c.

PROCESS.—Charges are 0.15 to 0.20 grams drying oil, 0.30 to 0.5 grams non-drying oil, and 0.6 to 0.8 grams of solid fat.

The charge is placed in a 250-c.c. stoppered flask and dissolved in 10–20 c.c. chloroform. 30 c.c. of the iodine solution are added from a burette, and the flask, loosely stoppered, is allowed to stand, with occasional shaking, 4 hours in a dark place. If the solution is not clear, more chloroform must be added; nor should the solution be decolorized. 100 c.c. water and 20 c.c. of KI solution are added, and any iodine on the stopper is washed into the flask with the KI solution. More KI solution is added if the iodine is not all out of the chloroform. The excess of iodine is determined by an $\frac{N}{10}$ solution of sodium thiosulphate, shaking the flask toward the end of the reaction, so that any iodine held in the chloroform may be taken up by the KI solution. A blank is run.

100 grams of butter fat absorb	about 33	grams	iodine.
100 grams of oleomargarine absorb	over 62	"	"
100 grams of commercial mixtures absorb	over 50	"	"

THE REICHERT-MEISSL VALUE (VOLATILE FATTY ACIDS)

(U. S. Agr. Bulletin, No. 13, p. 195)

represents the number of c.c. of $\frac{N}{10}$ KOH required to neutralize the volatile fatty acids obtained from 5.0 grams of oil or fat.

Reichert value is on 2.5 grams oil or fat.

Reichert-Meissl value is on 5 grams oil or fat.

Method is comparative.

References: Zeit. Anal. Chem., 18, p. 68.

Ding. Polytech. Journ., 233, p. 229.

5 grams are placed in a 250-c.c. dry round-bottom flask, and 2 c.c. KOH solution (100 grams KOH : 58 c.c. water) are added. A cork stopper is inserted into the neck of the flask and tied down with string. The saponification is completed by placing the flask on a steam-bath. During the saponification (which requires an hour) great care must be taken that no fat is allowed to rise on the side of the flask to a point where it cannot be reached by the alkali. In order to avoid this difficulty, the flask can only be gently rotated during the saponification. At the end of one hour the flask is allowed to cool, and when cold the stopper is removed.

To dissolve the soap add 80 c.c. of water, and warm on a steam-bath, with occasional shaking.

When the soap solution has cooled to about 60° C., the fatty acids are separated by adding 60 c.c. of dilute H_2SO_4 (25 c.c.: 1000).

The flask is now restoppered as before, and the fatty-acid emulsion is melted by replacing the flask on the steam-bath. According to the nature of the fat examined, the time for the fusion of the fatty-acid emulsion may vary from a few minutes to hours.

After the fatty acids are completely melted, which can be determined by their forming a transparent oily layer on the surface of the water, the flask is cooled, the cork is removed, and a few pieces of pumice-stone added. The pumice-stone is prepared by heating it red-hot and throwing it into distilled water, and keeping it there until used. Attach the flask to a condenser and slowly heat with the naked flame for the distillation of the volatile fatty acids. The heating is regulated so that 110 c.c. of distillate is collected in exactly 30 minutes. The distillate should be received in a flask graduated to 110 c.c.

The distillate, after being thoroughly shaken, is filtered through a perfectly dry filter-paper, and collected in a 100-c.c. graduated flask.

Titrate with $\frac{N}{10}$ KOH or $\frac{N}{10}$ $Ba(OH)_2$, using phenolphthalein as indicator. Titrate until the pink color formed lasts 2 minutes. A blank should be run.

Butter fat requires 28 c.c. for 5 grams; oleomargarine, 1 c.c.

THE HEHNER VALUE (INSOLUBLE FATTY ACIDS)

represents the percentage of insoluble fatty acids in an oil or a fat.

Reference: Zeit. für anal. Chem., 16, p. 145, modified.

3–4 grams of the substance are placed in a 250-c.c. flask, using a glass rod and hot alcohol to aid in transfer. Make the solution up to 50 c.c. with alcohol, and add 1–2 grams of pure stick caustic potash. Heat the mixture on the steam-bath, shaking continually, until the addition of a few drops of water causes no turbidity. This should not require over 10 minutes. Evaporate the solution (to drive off the alcohol) to soft dryness of a white color, with no smell of alcohol.

Dissolve the residue in water, transfer the solution to a 1000-c.c. beaker, and make the solution up to 700 c.c. with hot water.

Heat the solution on the steam-bath, making it decidedly acid with hydrochloric acid, and continue to heat until the fat rises to the top. Allow the solution to become cold, and filter through a dried

weighed filter. Wash out the beaker with hot water, and wash the precipitate with the same until the filtrate and washings give a neutral reaction to litmus paper. Allow the fat on the paper to become solid, transfer it with the filter-paper to weighing-bottle, and dry in air-bath at 100° C. to constant weight. This takes 2–3 hours.

Nearly all Hehner values = 95–97. Exceptions: Butter fat, 87.5; cocoanut oil, 88.6–90.5; palm-nut oil, 91.1; croton oil, 89.0.

Note.—Oleomargarine = 95 +.

THE ACETYL VALUE

represents the amount of hydroxy acids or higher aliphatic alcohols in a fat, in milligrams KOH required to neutralize the acetic acid obtained on saponification of 1.0 gram of the acetylated acids.

Theory of Benedikt.—Hydroxylated fatty acids, on being heated with acetic anhydride, exchange the hydrogen of their hydroxyl group or groups with the radical of acetic acid.

Acids containing no hydroxyl group remain unaltered.

Reference: J. S. C. I., 1890, p. 846.

Theory of Lewkowitsch.—According to Benedikt's theory: Acids containing no hydroxyl group remain unaltered; hence the amount of caustic required to neutralize the fatty acids before and after treatment with acetic anhydride should be the same. Lewkowitsch has shown this statement to be untrue, because oleic, palmitic, stearic, capric, lauric, and cerotic acids, containing no hydroxyl group, were found to give definite acetyl values.

This is explained by the following theory: As the mixed anhydrides of the higher fatty acids and acetic acid could not have been formed by the action of acetic anhydride, the anhydrides of the fatty acids have been formed.

$$\begin{array}{ccccc} \text{Palmitic Acid.} & & \text{Acetic Anhydride.} & & \text{Palmitic Anhydride.} & & \text{Acetic Acid.} \\ \begin{matrix} C_{15}H_{31}COOH \\ C_{15}H_{31}COOH \end{matrix} & + & \left.\begin{matrix} C_2H_3\text{—}O \\ C_2H_3\text{—}O \end{matrix}\right\rangle O & = & \left.\begin{matrix} C_{15}H_{31}CO \\ C_{15}H_{31}CO \end{matrix}\right\rangle O & + & \begin{matrix} CH_3COOH \\ CH_3COOH \end{matrix} \end{array}$$

Reference: J. S. C. I., 1890, p. 660.

Method of Analysis.—50 grams of the fatty acid are boiled with 40 grams of acetic anhydride, with an inverted condenser, for two hours. The product is boiled with about 500 c.c. water, washed free of acid, and filtered. A charge of the acetylated product is saponified with alcoholic potash, and the alcohol is boiled off. The residue is distilled with dilute H_2SO_4, as is the determination of the Reichert-Meissl value. Any acetic acid formed by hydrolysis of acetyl derivatives is thus distilled over, and may be titrated by means of standard alkali, with phenolphthalein as indicator.

CHAPTER V.

CONSTANTS.

CLASS.	OILS AND FATS.	SPECIFIC GRAV:	
VEGETABLE OILS. **Drying.**	LINSEED	0.9316–0.9410 Lewk 15.5° C. 0.9254–0.9337 Cross Le Suer, 15.5° C. 0.934 Gill & Lamb,	172- 171- 170. 170- 173. B: 108. Su 170-
	Mixed Fatty Acids	0.9233 Allen, 15.5° (0.8925 Archbutt, 10 (Water 100° C.	178. 159. 179-
	HEMP-SEED	0.925–0.931 Allen, 1	143 157. 140. 148
	Mixed Fatty Acids		122. D 141
	WALNUT	0.925–0.926 Allen, 1	143 147. 144. Fa
	Mixed Fatty Acids		150.
	POPPY-SEED	0.924–0.937 Allen, 1	132. 136 137.
	Mixed Fatty Acids	0.8886 Archbutt, 10 (Water 100° =	139
Semi-drying. (1) COTTON-SEED OIL GROUP.	MAIZE	0.923 E. Hopkins & 15° C. 0.9245–0.9262 C.G.I 15° C.	121.1 122. 119.4 121.5 111.2 Fa Uns 8.64
	Mixed Fatty Acids		
	COTTON-SEED	0.922–0.930 Allen, 0.9465 Lavallois, 1	106 102– 106– 100.9
	Mixed Fatty Acids	0.8816 Archbutt, 10 (Water 100° C.	110.9 De 115.7 Liq. Ko
	SESAME GINGILI—TEEL	0.923–0.924 Allen,	106 F 102.7 108–1
	Mixed Fatty Acids		108.9 De 111.8

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No. I

GRAV	IODI	…UMENE.	SPEC. TEMP. REACTION.	MEAN MOL. WEIGHT.
Lewk Cross .5° C. amb,	Holde .6 E. H 77.25 L Benedi 87.7 Th ntyne 165.4 C Gill &	Gill & Lamb Hopkins mene De Negris & Raw 90–97 Gill & Lamb Special 105 Gill & Lamb	2.69 E. Hopkins 3.20–3.49 Thompson & Ballantyne 9.049 Gill & Lamb	
15.5° tt, 10 ° C.	illiams De Neg Lewko			283 Williams 307.2 Allen
llen,	l enedik e Negr kowit	ene Negris & Fabris		
	15.2 M li Negris			
llen,	l 1.7 Di 5.1 D	mene egris & Fabris		
	e Neg			
llen,	6 Lew 1 3.3 Di	ene Negris & Fabris		
utt, 10 00° =	egris			
kins & C.G.I.	Hop ith 9 Sp .1 C. .6 D .: Hopk	r s Method Negris & Fabris	6.381 Gill & Hatch	
Allen, lois, 1	Diet Wilso 9 W	en chbutt pkins ley Negris & Fabris	1.69 E. Hopkins Refined = 1.69–1.70 Thompson & Ballantyne Crude = 1.63 " 5.667 Gill & Hatch	
butt, 10 00° C.	4 M iams –14			275 Valenta 289 Williams
Allen,	te Die	ene utt Negris & Fabris		
	De			286 Valenta

CLASS.	OILS AND FATS.	SPECIFIC GRA
(2) Rape-oil Group.	Rape	0.9112–0.9175
	Mixed Fatty Acids	0.8758 Archbutt, (Water 100° C
(3) Castor-oil Group.	Croton	0.942 at 15° C.
	Mixed Fatty Acids	
	Castor	0.9611–0.9736 at 1
	Mixed Fatty Acids	
Non-drying.	Arachis	0.9163–0.922 at 15
	Mixed Fatty Acids	0.8475 Archbutt, (Water 100° C
	Olive	0.9178–0.9196 Cla 0.916–0.918 (203 s De Negris & F
	Mixed Fatty Acids	0.8749 Archbutt, (Water 100° C
	Olive-kernel	0.9202 Valenta
	Mixed Fatty Acids	
Animal Oils. Marine. (1) Fish-oil Group.	Menhaden	0.927–0.933 Allen
	Mixed Fatty Acids	
	Sardine	0.933 Fahrion, 15
	Mixed Fatty Acids	
	Japanese Sardine	0.916 Fahrion, 15
	Mixed Fatty Acids	
(2) Liver-oil Group.	Cod-liver	0.922–0.927 Krem 0.929 Allen, 15° C
	Mixed Fatty Acids	

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IC GR	ODINE	JMENE.	SPEC. TEMP. REACTION.	MEAN MOL. WEIGHT.
175	4 Cross veri Dietrich	pkins mene hes egris & Fabris	1.24 E. Hopkins 1.25–1.44 Thompson & Ballantyne	
hbutt, 100° C	Mora De Ne 7 Walle			321.2 Allen 307 Williams 314 Valenta
C.	7 Lewk			
6 at	ch Thomp tyne Deerin	kins tt ne	0.91 E. Hopkins 0.89–0.92 Thompson & Ballantyne	
	Moraw i iams			290–295 Wright 306.6 Allen 292 Williams
at 15	re Dietrich .82 Cro	ne Negris & re	1.05–1.37 Thompson & Ballantyne	
utt, o° C	Moraw i e Negri 3.5 Wall			281.8 Allen
Cla 03 s & F	Negris mples) a = 77. ossley &	kins Archbutt nples), Jean's	0.95 E. Hopkins 0.89–0.95 Thompson & Ballantyne 4.762 Gill & Hatch	
itt, o° C	awski & liams			279.4 Allen 286 Williams
	bl			
len	rchbutt ompson ll & Lam	chbutt & Lamb	3.06 Thompson & Ballantyne	
15	hrion			
15	ion wkowits			
m C	Kremel 52.6 Diet .4 Lewk	aumene s	2.72 Thompson & Ballantyne 8.002 Gill & Hatch	

No. III

CLASS.	OILS AND FATS.	SPECIFIC GRAVI'
(s) BLUBBER-OIL GROUP.	SEAL	0.9245 Allen, 15.5° C 0.9155-0.926, 15° C.
	Mixed Fatty Acids	
	WHALE	0.9301 Allen, 15.5° C.
	Mixed Fatty Acids	0.8922 Archbutt, 100° (Water 100° C. =
	DOLPHIN BLACKFISH	0.9175-0.918 Schaedle 15° C.
	Mixed Fatty Acids	
	PORPOISE	0.926 Allen, 15.5° C. 0.937 Chevreul, 16° C
	Mixed Fatty Acids	
Terrestrial.	NEAT'S-FOOT	0.914-0.916 Allen, 15° 0.9152-0.9165 Jean, 15
	Mixed Fatty Acids	
	SHEEP'S-FOOT	0.9175 Schaedler, 15° (
	Mixed Fatty Acids	
	HORSE'S-FOOT	0.913 Schaedler, 15° C 0.9202-0.9205 Jean, 15 0.927 Amthor & Zink,
	Mixed Fatty Acids	
	LARD OIL	0.915 Allen, 15.5° C. 0.9122 Long, 20° C. 0.915-0.916 Gill, 15° C
	Mixed Fatty Acids	
	TALLOW OIL	0.916 Gill, 15° C. 0.9095 E. Hopkins & C burn, 20° C.
	Mixed Fatty Acids	
SOLID FATS. Vegetable.	COTTON-SEED STEARIN	0.91884 Crampton, 15° 0.923 Schaedler, 15° C
	Mixed Fatty Acids	

A No. III

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GRAVITY	...MAUMENE.	SPEC. TEMP. REACTION.	MEAN MOL. WEIGHT.
, 15.5° C. el; , 15° C. dle; hon; wits		2.12–2.29 Thompson & Ballantyne	
15.5° C. son	= 91 Allen 85–86 Dodd = 92 Archbutt 61 Jean	Pale = 1.57 Thompson & Ballantyne	
itt, 100°			
° C. = 1; Schaedler	Bod; Jaw		
5.5° C.; l, 16° C.	0.9; 6.8		
len, 15°; an	Jean	3.286 Gill & Lamb	
ean, 15	Jean		
kow			
er, 15°			
, 15° C; ean, 15; Zink,	ewko; r & Z		
° C.; C.; 15° C; l	hweitzer & Lung- ill		
pkins; ns & (	l		
1, 15°; 15° Cegris; Lewko			
egris			

No. IV

CLASS.	OILS AND FATS.	SPECIFIC GRAVITY
SOLID FATS. Vegetable.	VEGETABLE TALLOW (CHINA)	0.918 Thomson & Woo 15° C.
	Mixed Fatty Acids	
	PALM OIL	0.921 Tate, 15° C. 0.945 Schaedler, 15° C.
	Mixed Fatty Acids	0.8701 Archbutt, 100° C (Water 100° = 1)
	COCOA BUTTER	Fresh: 0.95–0.952 Hager, 15° Old: 0.945–0.946 Hager, 15
	Mixed Fatty Acids	
	PALM-NUT OIL	0.952 Schaedler, 15° C. 0.9119 Allen, 40° C. (Water 15.5° C. =
	Mixed Fatty Acids	
	COCOANUT OIL	0.9115 Allen, 40° C. (Water 15.5° C. =
	Mixed Fatty Acids	0.8354 Allen, 98° C. (Water 15.5° C. =
	MYRTLE WAX	0.995 Allen, 15° C. 0.875 Allen, 98–99 (Water 100° C. = 1
	Mixed Fatty Acids	
	JAPAN WAX	0.963–0.978 Hager, 15° 0.918 Allen, 60° C. (Water 15.5° C. = Bleached: 1.0–1.006 Schaedler, 0.9985 E. Hopkins & burn Unbleached: 1.0021 E. Hopkins & burn
	Mixed Fatty Acids	0.848 Allen, 98° C. (Water 15.5° C. =

OF No. IV

es, t

INE.	AUMENE.	SPEC. TEMP. REACTION.	MEAN MOL. WEIGHT.
wkow gris & Negr			
witsch is & F e Ne			
on			
			273 Tate 270 Allen 263 Williams
nger rich gris & Lewko Hopk			
ris & I			
lenta orawsl			
vski &			211 Valenta
ilson gris &			
Moraws s			196–204 Wright 201 Williams Ceylon: 211 Lewkowitsch
			243 Allen
kowits d: opkins opkins			
			265.3 Allen

No. V

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or t

CLASS.	OILS AND FATS.	SPECIFIC GRAVIT	I
SOLID FATS. **Animal.**	HORSE FAT	Kidney: 0.932 Amthor & Zin Neck: 0.933 Amthor & Zin Leaf: 0.9319 Amthor & Zi 15° C. 0.9189 Filsinger	y: Am Am Amtl alma singe
	Mixed Fatty Acids		7.1 K
	GOOSE FAT	0.909 Young, 37.8° C (Water 37.8° C. =	rban
	Mixed Fatty Acids		
	LARD	0.931–0.932, 15° C. 0.934–0.936, 15° C.	3.8 D ican: Schw tz ed L –66.3
	Mixed Fatty Acids	0.8445 Allen, 99° C. (Water 15.5° C. =	Willia
	BEEF MARROW		ewko
	Mixed Fatty Acids		ewko
	BONE FAT	0.914–0.916 Allen, 15	9.6 W 8 Val
	Mixed Fatty Acids		= 5 d =
	BEEF TALLOW	0.943–0.953, 15° C. 0.86 Koenig, 100° C. (Water 15° C. =	bl 4 Wi 7.9 F trich
	Mixed Fatty Acids	0.8698 Archbutt, 100 (Water 100° C. =	Willia 2 Ber d: –92.4
	MUTTON TALLOW	0.937–0.953, 15° C.	6.2 W Thörn
	Mixed Fatty Acids		d: Wall
	BUTTER FAT	0.911–0.94, 15° C. 0.9074–0.914, 100° C. (Water 100° C. =	7.9 W mples ample 5.1 H
	Mixed Fatty Acids		

STANT No. V

these tabl

IODINE.	AUMENE.	SPEC. TEMP. REACTION.	MEAN MOL. WEIGHT.
thor & Zi thor & Zir thor & Zin an er			
Kalman			
& Spitzer			
Dietrich : eitzer & ard: 7 Wiley	lehner mbühl mbühl ley	Prime: 3.715 Gill & Hatch No. 1 = 4.096	
ns			
owitsch			
witsch			
Wilson enta			
4 5·7–57·3			
son ilsinger &		3.348 Gill & Hatch	
ns semann Wallenst			270–285 Wright
Wilson er			
nstein			
Voll = 33.32 = 19.1 M Hübl			

No. VI NST

the

CLASS.	WAXES.	SPECIFIC GRAVITY.	E FA TI OLEI
LIQUID.	SPERM OIL	0.875–0.884 Allen, 15.5° C. 0.833 Allen, 99° C.	= 2.6 = 0.2 n = 1
	Mixed Fatty Acids	0.899 Allen, 15.5° C.	
	ARCTIC SPERM OIL	0.8808 Allen, 15.5° C. 0.876–0.881, 15° C. 0.8274 Allen, 98°–99° C (Water 15.5° C. = 1)	.97
	Mixed Fatty Acids		
SOLID. Vegetable.	CARNAÜBA WAX	0.99–0.999 at 15° C.	
	Mixed Fatty Acids		
Animal.	WOOL FAT	Crude = 0.973 at 15° C Refined = 0.973 at 15°	
	Mixed Fatty Acids		
	BEESWAX	0.962–0.966 at 15° C., Dietrich	
	Mixed Fatty Acids		
	SPERMACETI CETIN	0.943 Schaedler, 15° C 0.960 Dietrich, 15° C.	
	Mixed Fatty Acids		
	INSECT WAX	0.970 at 15° C.	
	Mixed Fatty Acids		

'AN No. VI

se t

TTY RMS AC		SPEC. TEMP. REACTION.	MEAN MOL. WEIGHT.	ASH.
4 9 ·97–3		1 00 Thompson & Ballantyne		
			281–294 Allen 305 Williams	
		0.93 Thompson & Ballantyne		
				0.43
			Of mixed alcohols: 239 Lewkowitsch	

TABLE I.

ARRANGEMENT OF THE OILS, FATS, AND WAXES ACCORDING TO SAPONIFICATION VALUE.

Class.	Oil, Fat, or Wax.	Saponification Value of Oil, Fat or Wax.			Saponification Value of Mixed Fatty Acids.		
		Lowest	Highest	Mean.	Lowest	Highest	Mean.
Marine Animal Oil...	Dolphin-jaw Oil			290.0			
" " "	Porpoise-jaw Oil (skimmed)	253.7	272.3	263.0			
Vegetable Fat........	Cocoanut Oil	246.2	268.4	257.3			
" "	Palm-nut Oil			247.6	258	265	261.5
" "	Carapa Oil			239.0			
Animal Fat..........	Butter Fat	225.0	230.0	227.5			
Semi-drying Veg. Oil	Curcas Oil	210.2 (192.5)	230.5	220.3			
Vegetable Fat........	Japan Wax	214.0	222.4	218.3			
Marine Animal Oil...	Porpoise Oil	216.0	218.8	217.4			
Semi-drying Veg. Oil	Croton Oil	210.3	215.0	212.7			201.0
Drying Vegetable Oil	Japanese Wood Oil			211.0			
Vegetable Fat	Myrtle Wax	205.7	211.7	208.7			
Marine Animal Oil...	Whale Oil	188.5	224.4	206.5			
Animal Fat..........	Beef Marrow			199.6			
Vegetable Fat........	Palm Oil	196.3	202.5	199.4	206.5	207.3	206.9
" "	Laurel Oil	197.5	198.9	198.2			
Marine Animal Oil...	Dolphin-body Oil			197.3			
Vegetable Fat	Cocoa Butter	192.0	202.0	197.0			
Animal Fat..........	Beef Tallow	193.2	200.0	196.6			197.2
" "	Horse Fat	195.1	197.1	196.1	202.6	202.7	202.6
" "	Lard	195.3	196.6	196.0			
Terrestrial Animal Oil	Horse's-foot Oil	195.0	196.8	195.9			
" " "	Lard Oil	195.0	196.0	195.5			
Animal Fat..........	Mutton Tallow			195.2			
Non-drying Veg. Oil..	Tea-seed Oil	194.0	195.5	194.8			
Vegetable Fat	Cotton-seed Stearin	194.6	195.1	194.8			
Terrestrial Animal Oil	Sheep's-foot Oil			194.75			
Non-drying Veg. Oil..	Hazelnut Oil	191.4	197.1	194.2			
Vegetable Fat	Mowrah-seed Oil	188.4	199.9	194.2			
Drying Vegetable Oil	Poppy-seed Oil	190.0	198.0	194.0			
Non-drying Veg. Oil..	Cherry-laurel Oil			194.0			
Semi-drying Veg. Oil	Cotton-seed Oil	191.0	196.6	193.8	203.9	208.0	206.0
" " "	Beechnut Oil	191.1	196.3	193.7			
Non-drying Veg. Oil.	Arachis Oil	190.0	197.0	193.5			
Drying Vegetable Oil	Sunflower Oil	(188) 193.0	194	193.5			201.5
Semi-drying Veg. Oil	Brazilnut Oil			193.4			
Drying Vegetable Oil	Walnut Oil	189.0	197.0	193.0			
Terrestrial Animal Oil	Tallow Oil	192.2	193.6	192.9			
Drying Vegetable Oil	Madia Oil			192.8			
Non-drying Veg. Oil..	Apricot-kernel Oil	(188) 192.2	193.1	192.7			194.0
Terrestrial Animal Oil	Neat's-foot Oil	191.0	194.3	192.7			
Marine Animal Oil...	Seal Oil	185.0	196.4	192.7	190.4	196.0	193.2
Semi-drying Veg. Oil	Sesame Oil	187.6	192.4	192.6			199.3

ARRANGEMENT ACCORDING TO SAPONIFICATION VALUE.

Class.	Oil, Fat, or Wax.	Saponification Value of Oil, Fat, or Wax.			Saponification Value of Mixed Fatty Acids.		
		Lowest	Highest	Mean.	Lowest	Highest	Mean.
Marine Animal Oil...	Cod-liver Oil	171.0	213.2	192.1			204.4
Non-drying Veg. Oil..	Almond Oil	187.9	196.1	192.0			
Drying Vegetable Oil	Hemp-seed Oil	190	193	191.5			
Non-drying Veg. Oil..	Olive Oil	185.0	196	191.5			
" " " ..	Plum-kernel Oil			191.5			200.5
Drying Vegetable Oil	Linseed Oil	187.6	(221) 195.2	191.4			198.8
Marine Animal Oil...	Japanese Sardine Oil	189.8	192.1	190.9			
Animal Fat..........	Bone Fat			190.9			200.0
Non-drying Veg. Oil..	Peach-kernel Oil	189.1	192.5	190.8			200.9
Semi-drying Veg. Oil	Maize Oil	188.0	193.4	190.7			198.4
Drying Vegetable Oil	Niger-seed Oil	188.9	192.2	190.6			
Marine Animal Oil...	Menhaden Oil	188.0	192.0	190.0			
Vegetable Fat	Vegetable Tallow	178.7	200.3	189.5	181.2	182.1	181.7
Non-drying Veg. Oil..	Olive-kernel Oil			188.5			
Semi-drying Veg. Oil.	Cameline Oil			188.0			
Drying Vegetable Oil	Lallemantia Oil			185.0			
Semi-drying Veg. Oil	Castor Oil	176.0	183.0	180.0			
" " "	Grape-seed Oil	178.4	179.0	178.7			187.4
" " "	Rape Oil	170.2	179.2	174.6			
" " "	Black Mustard Oil	174.0	174.6	174.3			
" " "	Hedge Mustard Oil			174.0			
" " "	Jambo Oil			172.3	173.8	174.0	173.9
" " "	White Mustard Oil	170.3	171.4	170.8			
Vegetable Fat	Nutmeg (Mace) Butter	153.5	161.0	157.3			
Marine Animal Oil...	Porpoise-jaw Oil (unskimmed)			143.9			
Liquid Wax..........	Sperm Oil	123.4	147.4	135.4			
" "	Arctic Sperm Oil	123.0	135.9	129.5			
Animal Wax	Spermaceti	108.1	128.0	118.1			
" "	Beeswax	87.8	107.0	97.4			
" "	Wool Fat	98.3	102.4	95.4			
Animal Fat..........	Goose Fat	92.4	95.9	94.2			
Vegetable Wax......	Carnaüba Wax	80.0	95.0	87.5			
Animal Wax.........	Insect Wax			63.0			

TABLE II.

ARRANGEMENT OF THE OILS, FATS, AND WAXES ACCORDING TO IODINE VALUE.

Class.	Oil, Fat, or Wax.	Iodine Value of Oil, Fat, or Wax.			Iodine Value of Mixed Fatty Acids.		
		Lowest	Highest	Mean.	Lowest	Highest	Mean.
Marine Animal Oil..	Sardine Oil			193.2			
Drying Vegetable Oil	Linseed Oil (fresh)	170.0	181.0	175.5	159.85	182.0	170.9
" " "	" " (comm.)	148.0	181.0	164.5	159.85	182.0	170.9
" " "	Lallemantia Oil			162.0			
Marine Animal Oil...	Menhaden Oil	148.0	160.0	154.0			
Drying Vegetable Oil	Hemp-seed Oil	140.5	157.7	149.1	122.2	141.0	131.6
" " "	Walnut Oil	143.0	152.0	147.5			150.5
Marine Animal Oil...	Seal Oil	125.0	152.4	138.7			
Drying Vegetable Oil	Poppy-seed Oil	132.6	143.3	138.0			139.0
Marine Animal Oil...	Cod-liver Oil	123.0	152.6	137.8			
Semi-drying Veg. Oil	Cameline Oil	132.6	135.3	134.0			136.8
Drying Vegetable Oil	Niger-seed Oil	126.6	133.8	130.2			
" " "	Sunflower Oil	118.0	133.3	125.7	124.0	134.0	129.0
Semi-drying Veg. Oil	Soja Bean Oil	121.3	122.2	121.8	115.0	122.2	118.6
Drying Vegetable Oil	Fir-seed Oil	118.9	120.0	119.5			121.5
" " "	Madia Oil	117.5	119.5	118.5			120.7
Marine Animal Oil...	Whale Oil	109.2	126.7	118.0			
Drying Vegetable Oil	Candlenut Oil			118.0			
Semi-drying Veg. Oil	Maize Oil	111.2	123.0	117.1	113.0	125.0	119.0
" " "	Kapok Oil			116.0			108.0
" " "	Curcas Oil	98.8	127.0	112.9			105.5
Non-drying Veg. Oil..	Cherry-kernel Oil	110.8	114.3	112.6	104.3	114.3	109.3
Semi-drying Veg. Oil	Cotton-seed Oil	102.0	117.0	109.5	110.9	115.7	113.0
Non-drying Veg. Oil..	Cherry Laurel Oil			108.9			112.1
Marine Animal Oil ..	Japanese Sardine Oil	96.0	121.3	108.7			
Semi-drying Veg. Oil	Beech-nut Oil	104.4	111.2	107.8			114.0
" " "	Sesame Oil	103.0	112.0	107.5	108.9	112.0	110.5
" " "	Brazil-nut Oil			106.2			108.0
" " "	Hedge Mustard Oil			105.0			
Non-drying Veg. Oil..	Apricot-kernel Oil	(96.2) 100.0	108.0	104.0	102.6	103.8	103.2
Semi-drying Veg. Oil	Croton Oil	101.7	104.7	103.2			
" " "	Rape Oil	(94.1) 99.0	106.0	102.5	96.3	103.1	99.7
" " "	Black Mustard Oil	96.0	(110.5) 106.0	101.0			109.6
Non-drying Veg. Oil..	Plum-kernel Oil	100.2	100.4	100.3	102.0	104.2	103.1
Marine Animal Oil...	Dolphin-body Oil			99.5			
Non-drying Veg. Oil..	Almond Oil	93.0	101.9	97.5	93.5	96.5	95.0
" " "	Rice Oil			95.4			
" " "	Peach-kernel Oil	92.5	99.7	96.1	94.1	101.9	98.0
Semi-drying Veg. Oil	Jambo Oil	95.2	95.6	95.4	96.1	96.2	96.2
" " "	Grape-seed Oil			95.1	98.6	99.0	98.9
" " "	White Mustard Oil	92.1	97.7	94.9	94.7	95.9	95.3
Non-drying Veg. Oil.	Arachis Oil	85.6	103.0	94.3	95.5	103.4	99.5
Vegetable Fat	Cotton-seed Stearin	88.7	93.6	91.2			94.3
Non-drying Veg. Oil..	Tea-seed Oil			88.0			

ARRANGEMENT ACCORDING TO IODINE VALUE.

Class.	Oil, Fat, or Wax.	Iodine Value of Oil, Fat, or Wax.			Iodine Value of Mixed Fatty Acids.		
		Lowest	Highest	Mean.	Lowest	Highest	Mean.
Non-drying Veg. Oil..	Hazelnut Oil	83.2	88.5	85.9			90.1
Semi-drying Veg. Oil	Castor Oil	83.6	85.3	84.5	86.6	93.9	90.3
Non-drying Veg. Oil..	Olive Oil	79.0	(93.67) 88.0	83.5	86.1	90.2	88.2
Liquid Wax	Sperm Oil	82.5	84.0	83.3	83.2	88.1	85.7
Terrestrial Animal Oil	Horse's-foot Oil	73.7	90.3	82.0			
Non-drying Veg. Oil..	Olive-kernel Oil			81.8			
Liquid Wax	Arctic Sperm Oil	80.4	82.1	81.3	82.2	83.3	82.8
Animal Fat..........	Horse Fat	71.4	86.1	78.8	83.9	87.1	85.5
Marine Animal Oil...	Porpoise-jaw Oil (unskimmed)			76.8			
Terrestrial Animal Oil	Sheep's-foot Oil	74.0	74.4	74.2			
Vegetable Fat	Carapa Oil			72.1			
Animal Fat..........	Goose Fat			71.5			
Terrestrial Animal Oil	Lard Oil	56.0	85.0	70.5			
" " "	Neat's-foot Oil	69.3	70.4	69.9			
Vegetable Fat........	Laurel Oil	49.0	80.5	64.7	81.6	82.0	81.8
" "	Shea Butter	56.2	56.9	56.6	56.0	57.2	56.6
" "	Mowrah-seed Oil	50.1	62.0	56.1			56.6
Animal Fat.........	Beef Marrow			55.4			55.5
" "	Lard	46.0	64.0	55.0			64.2
Terrestrial Animal Oil	Tallow Oil	51.8	57.0	54.4			
Vegetable Fat........	Vegetable Tallow (refined)	52.2	53.0	52.6	54.1	54.8	54.5
" "	Palm Oil	51.5	52.4	52.0			
Animal Fat..........	Bone Fat	46.3	55.8	51.1	55.7	57.4	56.6
Vegetable Fat	Nutmeg Butter	31.0	52.0	41.5			
Marine Animal Oil...	Porpoise-jaw Oil (skimmed)	30.9	49.6	40.3			
Animal Fat..........	Beef Tallow	35.4	44.0	39.7	25.9	41.3	33.6
" "	Mutton Tallow	32.7	46.2	39.5			
Vegetable Fat	Vegetable Tallow (commercial)	32.1	45.2	38.7	34.2	47.0	40.6
" "	Cocoa Butter	32.0	37.7	34.9			39.1
Marine Animal Oil...	Dolphin-jaw Oil			32.8			
Animal Fat..........	Butter Fat	25.7	37.9	33.32			
Animal Wax.........	Wool Fat	25.8	28.9	27.4			17.0
" "	" " Lanoline	17.1	17.6	17.4			
Vegetable Fat.......	Palmnut Oil	10.3	17.5	13.9			12.00
Solid Vegetable Wax	Carnaüba Wax			13.5			
Vegetable Wax......	Myrtle Wax			10.7			
Solid Animal Wax....	Beeswax	8.3	11.0	9.7			
Vegetable Fat........	Cocoanut Oil	8.0	9.3	8.7	8.39	9.3	8.8
" "	Japan Wax (bleached)			8.52			
" "	Japan Wax (unbleached)	4.2	7.48	5.8			
Animal Wax.........	Spermaceti	0.00	4.09	2.5			
" "	Insect Wax			1.4			

TABLE III.

ARRANGEMENT OF THE OILS, FATS, AND WAXES ACCORDING TO REICHERT-MEISSL VALUE.

Class.	Oil, Fat, or Wax.	Reichert-Meissl Value of Oil. Lowest.	Highest.	Mean.
Marine Animal Oil............	Dolphin-jaw Oil			131.84
" " "............	Porpoise-jaw Oil (skimmed)			131.6
" " "............	" -body Oil	22.0*	46.9	35.0
Animal Fat..................	Butter Fat	24.5	32.0	28.25
Semi-drying Vegetable Oil....	Croton Oil	13.27	13.56	13.44
Marine Animal Oil............	Whale Oil	1.4*	25.00	13.20
" " "............	Dolphin-body Oil			11.2*
Vegetable Fat................	Cocoanut Oil	6.65	7.8	7.2
" "	Palmnut Oil			5.0
Marine Animal Oil............	Porpoise-jaw Oil (unskimmed)			4.16*
Semi-drying Vegetable Oil....	Castor Oil			3.4*
Marine Animal Oil............	Cod-liver Oil (commercial)	2.2*	4.2*	3.2*
Vegetable Fat................	Cocoa Butter			3.2*
Drying Vegetable Oil.........	Lallemantia Oil			3.1*
Liquid Wax..................	Arctic Sperm Oil			2.8*
" "	Sperm Oil			2.6*
Marine Animal Oil............	Menhaden Oil			2.4*
Animal Fat..................	Horse Fat	1.64	2.14	1.9
Semi-drying Vegetable Oil....	Maize Oil	0.66*	2.50	1.58
Animal Fat..................	Lard			1.10
Vegetable Fat................	Palm Oil			1.00
Semi-drying Vegetable Oil....	Cotton-seed Oil			0.95
" " "	Sesame Oil	0.70*	1.20	0.95
Drying Vegetable Oil.........	Walnut Oil			0.92
Semi-drying Vegetable Oil....	Curcas Oil	0.28	1.30*	0.76
" " "	Rape Oil	0.58	0.90	0.74
Drying Vegetable Oil.........	Linseed Oil	0.00	1.43	0.72
Non-drying Vegetable Oil.....	Olive Oil			0.60
Animal Fat..................	Beef Tallow			0.50*
Semi-drying Vegetable Oil....	Grape-seed Oil			0.46
Drying Vegetable Oil.........	Niger-seed Oil	0.11	0.63	0.37
Marine Animal Oil............	Seal Oil	0.14*	0.44*	0.29
" " "............	Cod-liver Oil (medicinal)	0.0	0.4*	0.20
	Most Oils	0.00	0.75	

* Reichert Value × 2 = Reichert-Meissl.

TABLE IV.

ARRANGEMENT ACCORDING TO HEHNER VALUE.

Class.	Oil or Fat.	Hehner Value of Oil or Fat.		
		Lowest.	Highest.	Mean.
Marine Animal Oil............	Dolphin-jaw Oil			66.28
" " "............	Porpoise-jaw Oil (skimmed)	68.44	72.05	70.25
Vegetable Fat................	Cocoanut Oil	82.35	90.50	86.40
Animal Fat...................	Butter Fat	86.5	88.00	87.25
Semi-drying Vegetable Oil....	Croton Oil	88.9	89.1	89.0
Vegetable Fat................	Palm-nut Oil			91.1
Non-drying Vegetable Oil.....	Tea-seed Oil			91.5
Semi-drying Vegetable Oil....	Curcas Oil	87.9	95.2	91.6
" " "	Grape-seed Oil			92.13
Drying Vegetable Oil.........	Lallemantia Oil			93.3
Marine Animal Oil....	Whale Oil			93.5
" " "............	Seal Oil	92.8	95.45	94.13
Animal Fat...	Goose Fat	92.4	95.88	94.14
" "...................	Lard	93.0	96.15	94.56
	All other Oils and Fats	94.0	97.00	96.0

TABLE V.

ARRANGEMENT ACCORDING TO ACETYL VALUE.

Class.	Oil.	Acetyl Value of Oil.		
		Lowest.	Highest.	Mean.
Semi-drying Vegetable Oil....	Castor	153.4	155.0	154.2
" " "	Olive-kernel			22.5
" " "	Cotton-seed	16.6	21.0	18.8
Drying Vegetable Oil.........	Poppy-seed			13.1
Semi-drying Vegetable Oil....	Sesame			11.5
Drying Vegetable Oil.........	Linseed			8.5
Semi-drying Vegetable Oil....	Croton			8.5
" " "	Curcas			8.36
Drying Vegetable Oil.........	Walnut			7.6
" " ".........	Hemp-seed			7.5
Semi-drying Vegetable Oil....	Rape			6.3
Non-drying Vegetable Oil.....	Peach-kernel			6.4
" " ".....	Olive		(36?)	4.7
" " ".....	Arachis			3.4

Series.	Acid.	Formula.	Melting Point.	Boiling Point, Ordinary Pressure.	Boiling Point, Press. MM.
Acetic	Acetic	$CH_3.COOH$	Liquid	+ 118.0	
$C_NC_{2N}O_2$	Butyric	$C_4H_8O_2$	Liquid	+ 162.3	
		$CH_3.CH_2CH_2COOH$	− 2° to + 2°		
	Isovaleric	$C_5H_{10}O_2$ $(CH_3)_2CHCH_2COOH$	Liquid	+ 173.7	
	Caproic Isobutylactic	$C_6H_{12}O_2$ $(CH_3)_2CH.CH_2CH_2COOH$	Liquid	abt. + 200.0	
	Caprylic	$C_8H_{16}O_2$ $CH_3(CH_2)_6COOH$	+ 16.5	+ 236.0	
	Capric	$C_{10}H_{20}O_2$ $CH_3(CH_2)_8COOH$	+ 31.3	+268 to 270.0	
	Umbelluric	$C_{11}H_{22}O_2$	+ 21 to 23.0	+275 to 280.0	
	Lauric	$C_{12}H_{24}O_2$	+ 43.6	+ 269.0 decomp. at ord. press.	+ 225.0 at 100 mm.
	Myristc	$C_{14}H_{28}O_2$	+ 53.8	"	+ 250.5 at 100 "
	Palmitic	$C_{16}H_{32}O_2$	+ 62.0	"	+ 215.0 at 15 " + 271.5 at 100 "
	Stearic	$C_{18}H_{36}O_2$	+ 69.2	+ 360.0 decomp.	+ 232.0 at 15 " + 291.0 at 100 "
	Arachidic	$C_{20}H_{40}O_2$	+ 75.0		
	Behenic	$C_{22}H_{44}O_2$	+ 77 to 78.0		
	Lignoceric	$C_{24}H_{48}O_2$ Isomer.	+ 81.0		
	Carnaübic	$C_{24}H_{48}O_2$ Isomer.	+ 72.5		
	Cerotic	$C_{27}H_{54}O_2$ or $C_{26}H_{52}O_2$	+ 78.0		
	Melissic	$C_{30}H_{60}O_2$	+ 90.0		
Oleic	Tiglic	$C_5H_8O_2$	+ 64.5	198.5	
$C_NH_{2N-2}O_2$	Hypogæic	$C_{16}H_{30}O_2$	+ 33.0		
	Physetoleic	$C_{16}H_{30}O_2$	+ 30.0		
	Oleic	$C_{18}H_{34}O_2$	pure + 14.0	+ 250.0 decomp. with super-heat'd steam	+ 232.5 at 15 mm. + 285.5 at 100 "
	Erucic	$C_{22}H_{42}O_2$	+ 33 to 34.0		+ 264.0 at 15 "
Linolic	Elæomargaric	$C_{17}H_{30}O_2$	+ 48.5		
$C_NH_{2N-4}O_2$	Linolic	$C_{18}H_{32}O_2$	Liq. at −18°		
Linolenic	Linoleic	$C_{18}H_{30}O_2$			
$C_NH_{2N-6}O_2$	Jecoric	$C_{18}H_{30}O_2$			
Ricinoleic	Ricinoleic	$C_{18}H_{34}O_3$	+ 16 to 17.0	decomp.	decomp. under 15 mm.
$C_NH_{2N-2}O_3$	Isoricinoleic	$C_{18}H_{34}O_3$	Resembles ri	cinoleic acid	
	Rapic	$C_{18}H_{34}O_3$			

SOLUBILITY OI

Lower members of acetic acid series miscible in water in all proportions, but this changes wit capric acid is only sparingly soluble. Higher acids insoluble in water. All fatty acids

COLOR.	ODOR.	TASTE.	DESCRIPTION.	SOURCE.
Colorless	Penetrati'g acid	Acid	Low temp., anhydrous Leafy cryst. + 16.7 = liquid	Spindle Tree
"	Fresh dist. } = Acetic + water = Rancid butter	Sour, burning	Oily liquid	6.0% butter fat
"	Putrid cheese		"	Porpoise, Dolphin, Blubber oils
	Sweat		"	Butter fat, Cocoanut oil
	Strong sweat		"	Human fat, Butter fat, Cocoanut oil
	Goat-like		Fine needles, cryst.	Butter, Cocoanut oil
	Faint	Irritating, disagreeable	Crystalline	6.0% California Bay Tree Chaulmoogra oil
			Large crystals solid	Laurel, Cocoanut oil, Spermaceti
			Crystal laminæ	Nutmeg butter, Cocoanut oil Otoba fat, Dika oil, Spermaceti
White	None	None	Tufts of fine needles cryst. or cryst. mass	Most oils and fats, Spermaceti, beeswax, large amount in palm oil, vegetable tallow, Japan wax
"	"	"	Laminæ or cryst. mass	Most oils and fats, especially in harder, as tallow
"			Small lustrous scales	Butter, Rape oils, Cocoa butter, and Arachis oil
"			Needles	Ben oils
"			Radiated structure or white flocks brittle when cool	Arachis oil
"				Carnaüba wax
			From alc. in delicate needles	Beeswax, Carnaüba wax, Chinese wax, Opium wax, wool fat
"			Silky lustre scales	Beeswax
			Triclinic columns	Croton oil
ite decomp. to brown	Decomposed = rancid		Needles	Arachis oil
"	"		Pure liquid	Sperm oil
e=colorless ld=yellow	" Rancid		Liquid	Most oils and fats, especially liquid
			Long fine needles	Rape oil, black and white mustard oils
			Rhombic plates	Japanese Wood oil
Yellow			Oil	Linseed and all drying oils
"	Fish		"	" "
				Sardine oil?
Colorless			Oil—6.0 in cold, solidifies to hard white mass	Castor oil
				Rape oil?

FATTY ACIDS.

isobutylactic acid to solubility, which rapidly decreases as the carbon atoms increase, and oluble in hot alcohol.

CHAPTER VI.

FATTY ACIDS.

DESCRIPTION AND EXAMINATION.

THE fatty acids with glycerol form the oils and fats. Almost invariably the fatty acids of the oils have an even number of carbon atoms. The fatty acids usually found in oils and fats are palmitic, stearic, and oleic, while next to these come linoleic and ricinoleic. Other fatty acids occur with these in oils and fats, but only in small quantities, and generally give the character to the fat in which they occur, as butyric in butter.

Fresh animal fats contain only a trace of free fatty acids.

Fresh vegetable fats may contain considerable free acid.

Oils and fats from unripe seeds contain more free acid than do those from ripe seeds.

The free acids in a vegetable oil and fat increase with the age of the oil; especially is this true of palm oil, palm-nut oil, and cocoanut oil, which decompose into free acid and glycerol.

It is worth noting that cotton-seed, being refined by alkali, contains no free fatty acids.

BALLANTYNE (J. S. C. I., 1891, p. 29) has shown that a fat has often become "rancid" before free fatty acids appear; hence it would seem that the liberation of fatty acids in a fat is not essential to cause "rancidity."

See "Rancidification of Fats," Chemical News, 1896, pp. 197, 246.

SEPARATION OF THE FATTY ACIDS FOR EXAMINATION.

This can be done by the complete saponification with alcoholic KOH of the oil or fat. The soap is dissolved in water and heated for some time in a steam-bath until all traces of the alcohol have been given off. Decompose the soap solution by the addition of a mineral acid, heating until the fatty acids are liberated and rise to the top, cool, and separate in a cake; or by means of a separating-funnel. Wash the fatty acids with water free of every trace of mineral acid.

TOTAL FATTY ACIDS.

Method by C. G. Hopkins. J. Amer. Chem. Soc., 1898, p. 955.

After the oil or fat has been saponified and separated, as in "Determination of Unsaponifiable Matter (Hönig and Spitz)" the soap solution is acidified with hydrochloric acid and separated in a separating-funnel.

The separated fatty acids are taken up with ether and the aqueous layer is drawn off. The ether layer is washed several times with water and transferred to a weighed flask. The ether is distilled off, and a few c.c. of absolute alcohol are added and driven off to remove all traces of water. Weight = total fatty acids.

For further identification of the fatty acids,

LEWKOWITSCH, J. S. C. I., 1890, p. 843.

C. G. HOPKINS, Amer. Chem. Soc., 1898, p. 957.

SOLIDIFYING POINT OF FATTY ACIDS.

DALICIAN'S METHOD—TITER TEST.

References: Dalican, Moniteur Scientifique, 1868.
Thorpe's Dic. Applied Chem., vol. III. p. 50.

Saponify the oil with alcoholic potash and decompose the soap with mineral acid (H_2SO_4), whereby the fatty acids are liberated.

A test-tube 5 inches long by $\frac{2}{8}$ in. in diameter is inserted into a rubber stopper by which the test-tube is fixed into the mouth of a bottle or flask.

The melted fatty acids are then poured into the warm test-tube until the tube is about $\frac{2}{8}$ full, and a thermometer, previously warmed, is suspended in the liquid. As the fatty acids begin to solidify, slowly stir the contents of the test-tube by the thermometer. At first the thermometer falls, but then begins to rise again and remains stationary for at least two minutes. The temperature thus indicated is the solidifying point.

FINKENER'S Method. J. S. C. I., 1889, p. 424.

This gives higher "Titer Nos." than Dalican's Method and shows no advantage.

QUANTITATIVE ANALYSIS OF FATTY ACIDS.

The analysis giving the constants for the fatty acids are the same as for the oils and can be found under the heading of Chapter IV as follows:

A measure of the Free Fatty Acids in a fat = Acid Value.

Percentage of the Total Fatty Acids " " " = Saponification Value.

For free fatty acids these two should be identical.

Volatile Fatty Acids	in 5 gr. fat	= Reichert - Meissl Value.
Insoluble Fatty Acids	" a fat	= Hehner Value.
Unsaturated Fatty Acids	" " "	= Iodine Value.

QUANTITATIVE ANALYSIS OF FATTY ACIDS.

LEWKOWITSCH, J. S. C. I., 1890, p. 843.

Fatty Acids. Amount shown by (1) Hehner value and Reichert-Meissl value;
(2) Köttstorfer value in terms of mgr. KOH.
- Soluble in water. Amount shown by Reichert-Meissl value.
- Insoluble in water, amount shown by Hehner value.
  - Saturated.
  - Unsaturated detection. Iodine value.
    - (1) $C_{18}H_{34}O_2$ yields on oxidation Dihydroxystearic Acid.
    - (2) $C_{18}H_{32}O_2$ " " " Tetrahydroxystearic Acid.
    - (3) $C_{18}H_{30}O_2$ " " " Hexahydroxystearic Acid.
    - (4) $C_{18}H_{34}O_3$ " " " Trihidroxystearic Acid.

Fatty Acids, Köttstorfer value.
- (1) Neutral Fats. Amount shown by Ether value.
- (2) Free Fatty Acids. Amount shown by Acid value.

CALCULATION OF THE MEAN MOLECULAR WEIGHT OF INSOLUBLE FATTY ACIDS.

These fatty acids are mixtures, and hence only the mean molecular weight can be determined.

Find the acid value in milligrams of KOH.

Molecular weight $= M : 56.1 :: 1 :$ Acid value. $M = \dfrac{56.1}{\text{Acid value.}}$

Acid.	Formula.	Molecular Weight.
Myristic..................	$C_{14}H_{28}O_2$	228
Palmitic..................	$C_{16}H_{32}O_2$	256
Linolenic..............	$C_{18}H_{30}O_2$	278
Linolic..................	$C_{18}H_{32}O_2$	280
Oleic....................	$C_{18}H_{34}O_2$	282
Stearic..................	$C_{18}H_{36}O_2$	284
Ricinoleic..............	$C_{18}H_{34}O_3$	298
Erucic..................	$C_{22}H_{42}O_2$	388

Most oils and fats contain fatty acids with molecular weights from 256 to 284.

RENARD'S ARACHIDIC TEST.

Arachis oil yields arachidic acid.

Original Method. Renard, Comptes Rend., 73, p. 1330.

Archbutt's Method. J. S. C. I., 1898, p. 1124.

REAGENTS.—(1) NaOH—50 grams NaOH in 100 c.c. water. (2) Alcohol 90%. (3) HCl. (4) Ether. (5) Lead acetate: 20% aqueous solution.

Ten grams of oil are saponified in a porcelain dish with 8 c.c. of the caustic solution and 70 c.c. of alcohol. Evaporate to 20 c.c. volume, and wash with water into a separating-funnel. Decompose the soap with hydrochloric acid, and shake out with ether to dissolve the liberated fatty acids. Two extractions with ether are sufficient. Wash the ether solution with water and then distil to dryness in a 250-c.c. flask. Heat the flask on a water-bath, and thoroughly dry the fatty acids by sucking out the vapor. Dissolve the dried fatty acids by adding 50 c.c. of 90% alcohol while the flask is still hot.

Add to solution (which should be as warm as 40° C. to keep in solution the crystals of lignoceric and arachidic acids) 5 c.c. of a 20% aqueous solution of lead acetate, then cool to 15° C., agitate, allow to stand ½ hour, filter, and wash only once with ether upon the filter. Wash the soaps back into the flask with ether from a wash-bottle, digest with ether for a short time, filter, and again rinse back.

After doing this four times the lead oleate will have been entirely dissolved out. Wash the lead soaps into a separating-funnel with ether before they have time to dry. Soap adhering to paper and flask is decomposed and transferred by rinsing with hot dilute HCl followed by ether.

Pour into the separating-funnel 20 c.c. of HCl (sp. gr. 1.10) to decompose the lead soaps, shake, draw off the aqueous liquid, and repeatedly wash the ethereal solution with small quantities of cold water until lead chloride is removed.

Distil off ether in a 250-c.c. flask and thoroughly dry the residual fatty acids as before. Take up again with 50 c.c. of 90% alcohol, and cork the flask and allow to cool to 15° C., when lignoceric and arachidic acids will crystallize out.

For a quantitative determination the process is carried on from this point by holding the temperature of the flask at 15°–20° C. for an hour, with occasional agitation; collect the crystals on a Gooch filter, using the filtrate for rinsing the flask. Wash the crystals several times with 90% alcohol: measure the filtrate and washings for correction. Wash the acids with 70% alcohol (in which these acids are in-

soluble) until the washings give no precipitate on the addition of water. These washings are thrown away.

If these steps are repeated, the product is purer.

The crystals are dissolved off the filter with boiling ether, distilled down, dried at 100° C. for an hour, and weighed. To this weight is added the amount dissolved by the 90% alcohol, as given in the following table.

Weight of Fatty Acids obtained by Renard's Process. Grams.	Correction per 100 c.c. of 90% Alcohol used for Crystallization and Washing. Grams.		
	15° C.	17.5° C.	20° C.
0.1 or less	+0.033	+0.039	+0.046
.2 "	.048	.056	.064
.3 "	.055	.064	.074
.4 "	.061	.070	.080
.5 "	.064	.074	.085
.6 "	.067	.077	.088
.7 "	.069	.079	.090
.8 "	.070	.080	.091
.9 and upwards	.071	.c11	.091

CHAPTER VII.

UNSAPONIFIABLE MATTER.

"SAPONIFICATION," according to Alder Wright, was originally used to designate the chemical change taking place when soap is prepared by the action of alkali upon fixed oils and fats; but this definition has been extended to comprise all parallel changes occurring where various classes of "compound ethers" are broken up into a metallic salt of the organic acid and an alcoholiform product. The author would still further extend this definition by saying that the term has been extended to comprise all parallel changes occurring where various classes of "compound ethers" are broken up into an organic acid or its metallic salt and an alcohol. Hence the action of alkali, acids or steam upon fixed oils and fats constitutes saponification.

Under the term "unsaponifiable matter" are embraced the following substances, unacted upon by alkalies and insoluble in water.

Caustic potash, in alcoholic or aqueous solution, is the agent used for saponification in the chemical analysis of oils, fats, and waxes.

The principal unsaponifiable substances met with in oil analysis are:

The true unsaponifiable matter	Unsaponifiable	Mineral oils Coal-tar oils Paraffin wax Cerasin Aliphatic alcohols
	Partly saponifiable	Resin oils
Confounded with unsaponifiable matter unless due care is taken	Partly saponifiable	Waxes
	Hard to saponify	Lactones
	Almost entirely saponifiable	Resin

All good cylinder oils are a mixture of fatty acids and mineral oils.

Most "blown oils" are a mixture of fatty acids and mineral oils.

Mineral oils are miscible with all fatty oils excepting castor oil, and if castor oil is fixed with other fatty oils it can be made to mix with mineral oil.

Detection of the Unsaponifiable Matter. Holde, J. S. C. I., 1889, p. 735.

Heat a small piece of caustic potash with about 5 c.c. absolute alcohol in a test-tube. To this solution add a few drops of oil, and reheat. Pour in a few c.c. of water, and if the solution becomes turbid unsaponifiable matter is indicated.

Quantitative Determination of the Unsaponifiable.

There are many gravimetric and volumetric methods for this determination, and those selected have proven most successful.

DETERMINATION OF UNSAPONIFIABLE MATTER.

MINERAL OIL AS AN ADULTERANT.

Method of Hönig and Spitz. J. S. C. I., 1891, p. 1039.

7–10 grams of the oil or fat are placed in a 250-c.c. flask; 20–25 c.c. of alcoholic KOH and 25 c.c. alcohol are added. The flask is connected with an invert cooler and the contents boiled for 5–10 minutes, then 30–40 c.c. of water are added and the whole is heated to boiling.

After cooling, the contents of the flask is brought into a separating-funnel; the flask is washed out with a little 50% alcohol and with 50 c.c. petroleum ether (40°–70°); both washings being added to the contents of the separating-funnel. The whole is then thoroughly shaken. The petroleum ether separates completely from the alcoholic soap-solution. The alcoholic soap-solution is run into a beaker or flask, and the ether is washed two or three times with 50% alcohol, the washings being added to the soap-solution. The petroleum-ether solution is then run into a tared Erlenmeyer flask. The alcoholic soap-solution is again washed with separate portions of petroleum ether until no stain is left on paper. As a rule three washings are enough.

The petroleum ether is washed each time with 50% alcohol as above.

The united petroleum-ether extractions are distilled, bumping being prevented by the use of a platinum spiral (previously weighed for tare). The little petroleum ether left after distilling is removed by blowing hot air through the flask. In case the original oil con-

tains no easily volatile petroleum oil (which can almost always be told by the smell) instead of blowing hot air through the flask, the flask may be heated in an air-bath until a visible vapor begins to rise. The flask is then covered, cooled, and weighed.

The substance in the flask = unsaponifiable matter.

It is sometimes found that the separation is not rapid or well defined. If such is the case, the addition of a volume of water equal to the volume of the soap-solution often prevents the emulsion.

(1) LIQUID UNSAPONIFIABLE MATTER.

SPECIAL DETERMINATIONS AND TESTS.

Mineral Oil.

Mineral oils and resin oils are told by their fluorescence. Fluorescence is also given by some fatty oils and oleins. Mineral oils are often deprived of fluorescence by the addition of nitrobenzol or nitronaphthalene.

Mineral oil *vs.* tar oils.

Difference told by the specific gravity.

Nitric Acid Test.—Add nitric acid (specific gravity 1.45).

Mineral oil + HNO_3 = slight rise in temperature.
Tar oil + HNO_3 = decided rise in temperature.

Detection of Nitronaphthalene in Mineral Oils.

LEONARD, J. S. C. I., 1894, p. 69.

This is added to the mineral oil before adulterating an oil, in order to remove its fluorescence.

Nitronaphthalene is reduced to naphthylamine.

Gently warm a small quantity of oil with zinc dust and dilute hydrochloric acid, shaking from time to time. The fæcal odor of a-naphthylamine should be here noted. Separate the aqueous acid layer after reduction is complete by means of a separating-funnel. This liquid is divided into two portions.

Portion A. Neutralized with ammonia.	+	Ferric chloride = blue precipitate which changes to purple.				
Portion B. Make alkaline with sodic carbonate and extract with ether.		Evaporate and dissolve in alcohol.	+	Sodic nitrate and acidulate with acetic acid.	=	Yellow color, changing to crimson on addition of hydrochloric acid.

Detection of Resin Oil in the Unsaponifiable Matter.

Liberate the free resin acids in the regular way by saponification with alcoholic potash and acidulation with mineral acid. (See Separation of Fatty Acid.)

The resin acids separate in the form of brown viscid drops of characteristic odor.

Detection of Resin Oils by Color.

Liebermann-Storch Reaction. J. S. C. I., 1888, p. 136.

Shake 1–2 c.c. of the oil with acetic anhydride, warming the while. Cool and pipette out the anhydride and add one drop of sulphuric acid (specific gravity 1.53). Resin oil gives a violet color (fugitive), but can be seen if the solution is not too warm, and even in the following oils which give characteristic colors with the reaction:

Oil and Fat.	Color.	Oil and Fat.	Color.
Olive	Light green	Castor	Yellow
Sesame	Green-blue	Cocoanut	Yellow
Hemp-seed	Green	Palm-nut	Yellow
Linseed	Green	Beef Tallow	Yellow
Cotton-seed	Green	Bleached palm	Brown-yellow
Arachis	Red-brown	Bone-fat acids	Brown-yellow
Rape	Green-yellow	Whale Stearin	Brown-yellow
		Olein	Brown-yellow

Note that cholesterol gives this color reaction.

Burchard's Modification. Zeit. für Anal. Chem. 1892, p. 90.

Add a few drops of the oil to 2 c.c. chloroform and dissolve. Add 20 drops of acetic anhydride and one drop H_2SO_4 (specific gravity 1.53). Violet-pink color.

Note.—Cholesterol gives this color reaction.

Renard's Color Test.

Modified by Allen. Commercial Org. Anal. II. p. 463.

To 1 c.c. of oil add one drop of stannic bromide = violet color.

Stannic bromide is made by allowing *dry* bromine to fall drop by drop upon tin placed in a dry flask, which is kept cool. The product is dissolved in carbon bisulphide.

Quantitative Determination of Resin Oils.—See Twitchell's Method for Determination of Resin (Chapter VIII).

(2) SOLID UNSAPONIFIABLE MATTER.

EXAMINATION AND DETECTION.

Paraffin Wax in Mineral Oil. Pawlewski and Filemonewicz Chem. Soc. 1889.

Shake the oil sample in 10 times its volume of glacial acetic acid, and filter on a weighed filter; wash with glacial acetic acid and then with alcohol. Dry and weigh.

Solubility of paraffin wax in glacial acetic acid 1 : 1668.
heavy mineral oils 1 : 25–60.

Paraffin Wax in Candles. Donath, Dingl. Polytech. Jour. 208, p. 305.

Saponify 6 grams of candle material with alcoholic potash, drive off the alcohol and dissolve the soap in hot water and add barium chloride solution. Wash the barium soap on a filter, dry at 100° C., powder and extract the paraffin wax in a soxhlet with petroleum ether.

Quantitative Estimation of Paraffin, Cerasin, and Mineral Oils in Fats and Waxes.

F. M. HORN, J. S. C. I., 1888, p. 696.

Saponify the mixture, evaporate the mass to dryness, extract in a soxhlet with chloroform, which, unlike petroleum ether, does not dissolve any of the soap.

The solution in chloroform is then evaporated and the mineral oil weighed.

In the case of a wax, the chloroform will also contain the higher alcohols; these can be separated by digestion with acetic anhydride, which converts them into acetates soluble in excess of reagent. Filter them from the paraffin in a hot filter, and wash the paraffin first with acetic anhydride and then hot water. As long as the filter-paper is kept wet, no paraffin passes through; when washed, it is dried with the filter, dissolved in chloroform or petroleum ether. The solution is evaporated to dryness and weighed. Glacial acetic acid may be substituted for acetic anhydride, but is less suitable, as the acetates may separate out unless the solution is kept hot.

Quantitative Determination of Aliphatic Alcohols.

THEORY.—*Aliphatic alcohols* + KOH = *potash salt* + H_2.

Method of C. Hell. Liebig's Annalen, 223.269.

The oil, fat, or wax is heated to 300°–310° C. with soda, lime, and the hydrogen gas evolved is collected and measured.

Method of A. and P. Buisine. Monit. Scientif. 1890, p. 1127.

This is simply a modification of Hell's method, because it was found that soda lime alone did not give the required accuracy for the process.

The oil, fat, or wax is first mixed with an equal weight of caustic potash and is powdered and mixed with three parts of soda lime (1KOH : 2CaO). The heating is done in a strong flask and in an

enclosed bath of a liquid boiling above 250° C. The hydrogen gas is collected in a suitable gas-apparatus and measured at 0° C. 760 mm. pressure. All the gas should be given off after 2 hours' heating at 250° C.

Color Reactions for Cholesterol.—Isocholesterol and Phytosterol.

(1) SCHULZE'S REACTION.—*Cholesterol and Isocholesterol.*—Heat a very small amount of cholesterol with a few drops of conc. HNO_3 to dryness in porcelain = yellow stain. Add a little NH_4OH to stain = yellow-red tint.

(2) SCHULZE'S REACTION.—*Cholesterol, Isocholesterol, also Turpentine and Camphor.*—Mix a little cholesterol with a drop of

$$(3 \text{ pt HCl conc.} + 1 \text{ pt } 10\% \; FeCl_6).$$

Evaporate to dryness = violet-red color, changing to blue.

(3) LIEBERMANN-STORCH REACTION WITH BUCHARD'S MODIFICATION.—*Cholesterol and Resin Oil.* (See tests given for resin oil.)

Quantitative Estimation of Cholesterol and Isocholesterol.

Method of Lewkowitsch. J. S. C. I., 1892, p. 143.

THEORY.—(1) Alcohols form ethers.

(2) Unsaturated compounds form iodine saturation compounds. Cholesterol as acetate has saponification value 137.4, 132.4

$$(\text{theoretical } C_{26}H_{43}O.C_2H_3O = 135.5).$$

Cholesterol has iodine value = 68.9, 67.3

$$(\text{theoretical } C_{26}H_{44}OI_2 = 68.3).$$

METHODS.—(1) *Saponification of the Acetate.*—Charge 1.5–2 grams. Boil with 1½ times its weight of acetic anhydride in a flask with inverted condenser = $C_{26}H_{43}O.C_2H_3O$ precipitate.

Wash this precipitate on filter with warm water free of acid, and boil the precipitate (after washing) with alcoholic potash. Titrate back the excess of KOH.

(2) *Iodine Value of the Alcohol.*—Charge 0.5 gram. Dissolve the cholesterol in 50 c.c. chloroform and add 25 c.c. of an iodine solution and 25 c.c. of a mercuric bichloride solution. Titrate back the iodine with sodic thiosulphate.

These two methods are for pure cholesterol and isocholesterol, and at present are more a suggestion for future work than of practical value in mixed-oil work.

Method of Bömer. C. G. Hopkins, Jour. Amer. Chem. Soc. 1898 p. 954.

Saponify 50 grams of the oil with 20 grams KOH and 1000 c.c. 70% alcohol on a steam-bath. Transfer the soap to a separating-funnel with 200 c.c. of water, and shake out, first, with 500 c.c. ether, and, next, three portions of 250 c.c. ether. Distil off the ether and resaponify the residue with 2.0 grams KOH and 10 c.c. 70% alcohol. Transfer to separating-funnel with 20 c.c. water and shake out with 100 c.c. ether. Wash the ether solution four times with 10 c.c. water and transfer to weighed flask. Distil off the ether and weigh. Weight = cholesterol. Recrystallize from absolute alcohol and weigh. Cholesterol should give glistening plates which melt at 137–137.5° C.

CHAPTER VIII.

LACTONES—RESIN—GLYCEROL.

DETECTION AND ESTIMATION OF LACTONES.

BENEDIKT, J. S. C. I., 1890, p. 658.

LACTONES are saponifiable, but hard to saponify; therefore they are liable to be mistaken for unsaponifiable matter. For this reason the author considers them in this place.

In alizarin assistant and stearin from oleic acid quite large quantities of this inner anhydride of γ-hydroxystearic acid (stearolactone) are to be found.

The oil is taken and the fatty acids separated by saponification with alcoholic potash and liberation with mineral acid. Of these fatty acids the acid value and saponification should be the same. If lactones are present there will be an ether value, which corresponds to the lactone. Fatty acids containing lactones contain a definite ether value, and, if the molecular weight is known, the lactone can be calculated.

The ether value of pure stearolactone = 198.9, and if the data become sapon. value 190 and acid value 140,

$$\frac{100 \times 50}{198.9} = 25.13\% \text{ stearolactone.}$$

RESINS.

Resins constitute a class of vegetable or sometimes animal products which are solid or semi-solid.

They are insoluble in water, but soluble in alcohol, ether, and volatile oils.

We shall here treat of the more important resin, called colophony.

COLOPHONY—COMMON RESIN—ROSIN.

Colophony is the residue which remains after the volatile oil has been removed by distillation from the oleoresins, the crude turpen-

tines which exude from various species of coniferæ. It varies according to its derivation and method of production.

Browner-colored resins are the American, from Pinus Australis.

Lighter-colored resins are the Landes and Gironde, from Pinus Pinaster.

"White" resin of commerce owes its light yellow color to a slight opacity, due to the presence of small quantities of water.

Colophony is brittle, solid, with glassy fracture;
formula $C_{44}H_{62}O_4$;
faint odor of turpentine;
tasteless;
specific gravity about 1.07;
solubility: insoluble in water;
soluble in ether, chloroform, acetane, benzol, volatile oils, fixed oils, alcohol at 60° C., glacial acetic acid at 60° C.;
soluble in alkalies, forming resin soaps;
softens at 80° C., melts 100° C.–135° C.;
distils in current of steam without change;
consists essentially of abietic anhydride (Maly & Flückiger) (crystalline $C_{44}H_{64}O_5$).

Colophony is largely used as an adulterant.

DETECTION OF RESIN IN OILS, FATS, AND WAXES.

(1) Characteristic odor of itself and free fatty acid.

(2) Characteristic taste of itself.

(3) Resin raises specific gravity of an oil.

(4) *Barford's Test.*—Warm sample with dilute alcoholic solution of soda crystals [1 : 3 water : 7 alcohol (30%)], which dissolves the resin only. Add water, which precipitates out the resin.

(5) *Rödiger Test* (*Chem. Zeit.* 5, p. 498).—Boil 100 grams of oil with 7–8 grams of K_2CO_3 and 80–100 c.c. water for fifteen minutes. Cool to 50° C. and shake with petroleum ether. The resin soap in aqueous solution is drawn off and diluted with hot water. Add excess of salt and acidulate = resin as oily layer.

(6) *Liebermann-Storch Reaction.*—As given under the tests for Resin Oils (Chapter VII). The resin must be saponified with alcoholic potash and the resin acids liberated.

QUANTITATIVE DETERMINATION OF RESIN.

Twitchell's Method. J. S. C. I., 1891, p. 804.

SEPARATION OF RESIN FROM FATTY ACIDS.

THEORY.—

Fatty acids in absolute alcohol + HCl (gas) = ethyl ethers of fatty acids;

Resin acids in absolute alcohol + HCl (gas) = no change; also

All fatty acids combine to form ethers, which are neutral in alcoholic solutions and are unacted upon by alkali.

Resin Acid is unacted upon and is acid in alcoholic solution, and forms a soluble soap with alkali.

For these reactions to take place the temperature must be cold.

METHOD.—(1) *Gravimetric.* 2–3 grams of a mixture of fatty acids and resin are dissolved in 10 times their volume of absolute alcohol in a flask, and dry hydrochloric acid gas passed through in a moderate stream.

The flask is immersed in water to keep it cool.

After the gas has been passed in for about 45 minutes, the ethers begin to separate, floating on the surface of the liquid. As soon as the hydrochloric acid fails to be absorbed, the flask is removed and allowed to stand a half hour longer to ensure the complete combination of the alcohol and fatty acid.

It is diluted with about 5 times its volume of water and boiled until the acid-solution is clear, the ethers, with resin in solution, floating on top. To this is added some naphtha (74°) and the whole transferred to a separating-funnel, the flask being washed out with naphtha (74°).

The acid-solution is then run off and the naphtha-solution (which should measure about 50 c.c.) is washed once with water and then treated in the funnel with a solution of 0.5 grams KOH and 5 c.c. alcohol in 50 c.c. of water and agitated.

The resin is immediately saponified and the two layers separate. The solution of resin soap is run off and treated with acid. The resin is collected, dried, and weighed.

METHOD.—(2) *Volumetric.* The first steps of the volumetric method are the same as the gravimetric, excepting that the contents of the flask are washed out with ether instead of naphtha, and the ether-solution in the funnel is thoroughly washed with water until the wash-water is no longer acid. 50 c.c. of alcohol (previously neutralized) are then added and the solution is titrated with standard caustic, using phenolphthalein as indicator.

The combining equivalent of resin is 346, i.e., the weight of resin neutralized by 1 c.c. $\frac{N}{1}NaOH = 0.346$ grams.

From this data the percentage of resin found by titration can be estimated.

NOTE.—Unsaponifiable matter in the fat does not affect the process, but can be determined by the volumetric method in one operation, as follows: 2 grams of the fatty mixture are titrated with normal caustic soda and saturate *a* c.c. 2 grams are treated with hydrochloric gas and the above process followed, then filtered, and are found to saturate *b* c.c. Then

$$b \times 0.346 = \text{weight of resin,}$$
$$(a - b) \times 0.275 = \text{weight of fatty acid,}$$
(275 taken as combining weight of fatty acids.)
$$100 - \text{the combined weights} = \text{unsaponifiable matter.}$$

Volumetric method is the more rapid and accurate, although liable to give a trifle too high results.

WILSON'S MODIFICATION. J. S. C. I., 1891, p. 952.

This modification is given as a means of shortening the volumetric process.

Leave out the washing, and dissolve in alcohol direct. With methyl orange as an indicator, titrate with normal alkali; then add phenolphthalein as indicator and titrate to pink color. The alkali required in the first place is for the neutralization of the HCl, and is therefore neglected. The second titration is calculated to resin.

GLYCEROL.

The amount of glycerol, the base of the fatty acid glycerides of all oils and fats, is often desired, and for this determination the following method is given:

Quantitative Determination, Acetin Method.

THEORY.—Glycerol + Acetic Anhydride = $\frac{\text{Glyceryl Triacetate}}{C_3H_5(OC_2H_3O)_3}$.

This method must be divided into steps:

(1) Acetin Method for Oils and Fats, Lewkowitsch, J. S. C. I., 1889, p. 574.

(2) Acetin Method for Crude Glycerol, Benedikt & Cantor, J. S. C. I., 1888, p. 696.

(1) *Oils and Fats.*—Saponify the fat and liberate the fatty acids by means of sulphuric acid; separate out the fatty acids, and the

filtrate from them is treated with barium carbonate. Evaporate nearly to dryness, extract with ether-alcohol, and evaporate the solution thus obtained first by a gentle heat and then in a dessicator, leaving the crude glycerol.

(2) *Crude Glycerol.*—The crude glycerol is heated with 7–8 grams of acetic anhydride and about 3 grams anhydrous sodium acetate for 1–1½ hours with inverted condenser. Cool, add 50 c.c. water, and again heat (still with the condenser, as glyceryl triacetate is volatile in a current of steam) until it begins to boil.

When the oily deposit at the bottom of the flask is dissolved, the liquid is filtered from a white flocculent precipitate (which contains most of the impurities of the crude glycerol). Allow the liquid to cool, add phenolphthalein as indicator, and run in dilute caustic soda (20 : 1000) until the liquid is exactly neutral. Care must be taken that the neutrality point is not exceeded, as glyceryl triacetate is easily saponified.

Twenty-five c.c. of a known strength solution of caustic soda (1 : 10) are now added from a burette. Heat the mixture 15 minutes and titrate back the excess of alkali with $\frac{N}{2}$ hydrochloric acid. From the amount of alkali required to saponify the glyceryl triacetate is calculated the glycerol.

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